PHASE II INVESTIGATION
AURELIUS ROAD LANDFILL

II
MI

Prepared For

City of Lansing

By

Snell Environmental Group, Inc.
1120 May Street
Lansing, Michigan 48906

and

Keck Consulting Services, Inc.
4903 Dawn Avenue
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November, 1979

Revised December, 1979

Snell Environmental Group
Engineering · Planning · Research

December 10, 1979

Mr. Howard McCaffery
Director of Public Service
City of Lansing
732 City Hall
Lansing, Michigan 48933

RE: Phase II Investigation Aurelius Road Landfill

Dear Mr. McCaffery:

Pursuant to the City of Lansing's letter of authorization of May 31, 1979, Snell Environmental Group has completed the Phase II Investigation of the Aurelius Road Landfill.

This Phase II Investigation was conducted as a result of recommendations contained in a Phase I investigation conducted for the Tri-County Regional Planning Commission April 19, 1979. That Phase I report concluded, in part, that leachate emanating from the Aurelius Road Landfill was entering the groundwater flow system and that additional investigation was required to quantitively define the extent of leachate migration both horizontally and vertically.

The hydrogeologic investigation of this Phase II report, sections 1.0 to 3.2 was conducted by Keck Consulting Services, Inc. The preliminary soil analysis, Appendix IX, was conducted by Beery and Associates, Okemos, Michigan.

The Phase II report has been reviewed with City officials and with their input has been prepared for submission to MDNR for their review and to obtain their concurrence with the City's proposed remedial measures.

We at Snell Environmental Group appreciate the opportunity of working with the City on this endeavor. Should you have any questions concerning this report, please contact this office.

Very truly yours,

SNELL ENVIRONMENTAL GROUP, INC.

Peter F. Cole
Project Engineer

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Vice President

PFC/KJG/brs

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1.0 INTRODUCTION

Snell Environmental Group and Keck Consulting Services, Inc., have recently completed Phase II of the Hydrogeologic investigation for the City of Lansing's Aurelius Road Landfill. The Phase I report dated April 19, 1979, presented to Tri-County Regional Planning Commission, concluded that leachate from the landfill was entering the Saginaw Geological Formation. Because the Saginaw Formation is the principal source in the Lansing area for municipal, industrial, and private water supplies, this contamination is of major concern. The scope of Phase I investigation did not permit a determination of leachate movement horizontally and vertically within the Saginaw Formation.

The purpose of this Phase II investigation was to: 1) accurately determine the horizontal and vertical movement of leachate generated within the Aurelius Road Landfill; 2) provide a quantitative estimate of the leachate discharged to Sycamore Creek; 3) carry out additional sampling and analysis to verify previous analyses.

This report presents the results and recommendations of this Phase II study.

2.0 FIELD INVESTIGATION - MONITOR WELLS

In order to determine the vertical and horizontal extent of the leachate movement in the Saginaw Formation, five 4-inch diameter monitor wells were installed. Three of the monitor wells were installed through the landfill material (MW 1, MW 2, and MW 3) inside of the landfilled area, one was installed on the north edge of the landfill (MW 4), and the final well was installed on Ingham County Road Commission property northwest of the landfill (MW 5). The monitor well locations are shown in Exhibit A.

At each well location, a 4-inch diameter surface casing was set and cemented 10 feet into bedrock. The surface drilling was done using the mud rotary method. The remainder of the rock drilling was done using the air rotary drilling method. All of the monitor wells were drilled to approximately a 710-foot elevation. Bedrock drilling and water sampling were done in 10-foot intervals using a packer (seal) arrangement to isolate each 10-foot interval for water sample collection. Pumping for water sample collection was done by the airlift pumping method and static water levels were measured for each interval sampled when possible. The drilling, packer setting, and pumping were done by Hart Well Drilling Company under the supervision of Keck Consulting Services personnel.

The water samples collected were taken to Snell Environmental Group laboratory for analysis. After completion of the drilling and sampling work, the monitor wells were geophysically logged by Keck Consulting Services personnel.

A summary of the intervals sampled, static water level elevations, pumping time, and water quality parameters above the EPA recommended or enforceable limits for each monitor well is presented in Tables 1 through 5 of Appendix I. Laboratory analytical results by Snell Environmental Group for the samples collected are included in Appendix II. The borehole geophysical logs collected, driller's formation logs for the monitor wells and a profile through the installed monitor wells are included in Appendix VII and VIII. This profile is also included as Figure 2-1 on the following page for ease of reference.

Geophysical logs run on each monitor well included a natural gamma radiation (gamma-ray) log and formation resistivity log. These logs were used to assist in identification of the subsurface materials encountered at each well site. The gamma-ray log is a measurement of radiation naturally emitted by certain elements in the form of gamma-rays. In general, sandstone and limestone formations emit little gamma radiation and are recorded as low gamma-ray intensities, while shaly materials emit higher amounts of gamma radiation and thus are recorded as high gamma-ray intensities. The gamma-ray intensities were measured in count per minute (CPM).

The resistivity log (sometimes referred to as electric log) is a method of measuring the resistivity of materials encountered in the uncased portion of the hole. In general, low resistivities indicate cohesive formations (shale) and high resistivities indicate more porous, granular formations (sandstone). Limestone has a characteristically very high resistivity. The 2.5 foot electrode spacing is used to measure actual resistivity of the formation, while the 0.25-foot electrode spacing is used to more accurately

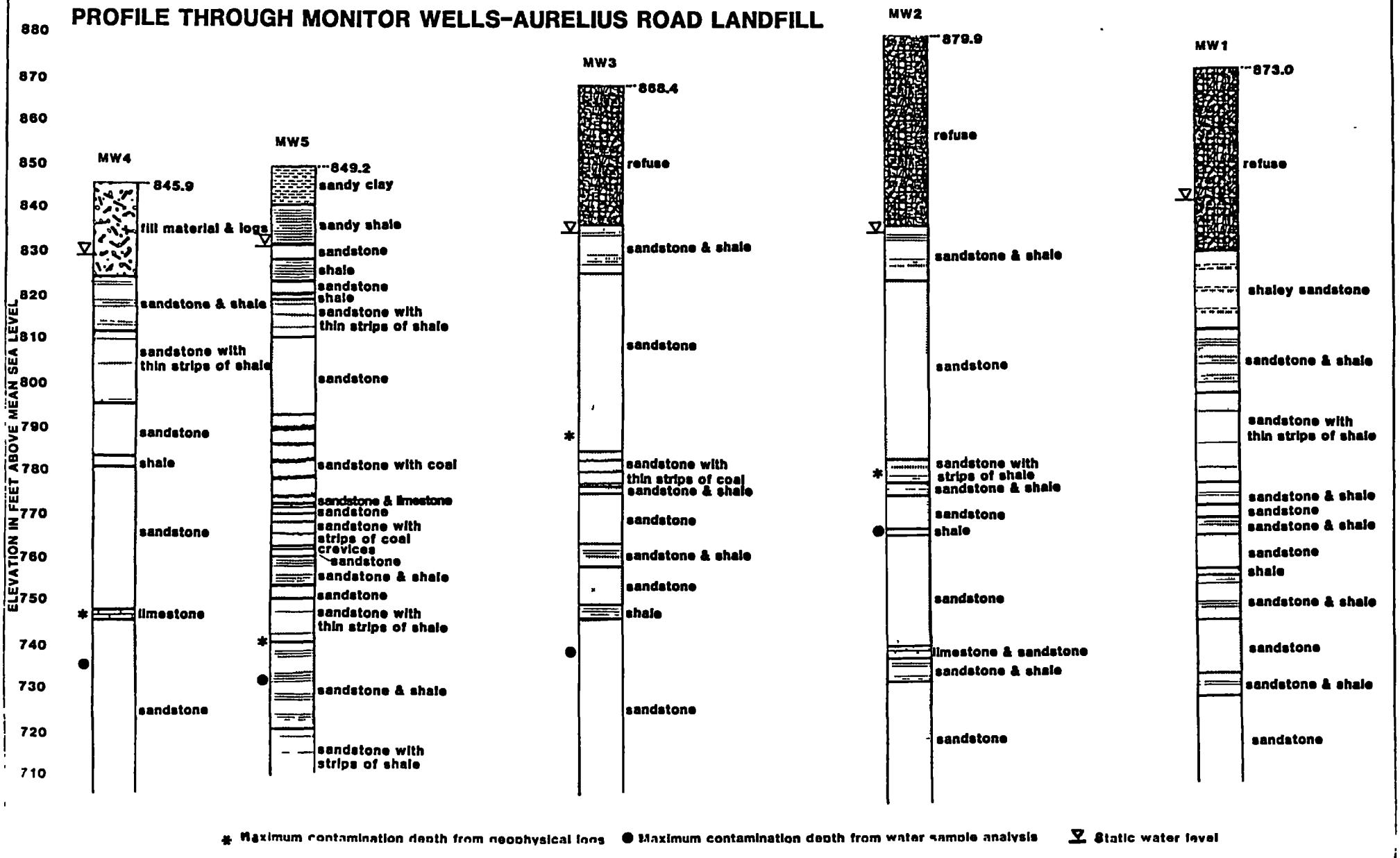
PROFILE THROUGH MONITOR WELLS-AURELIUS ROAD LANDFILL
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
880
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
710
MW4
845.9
fill material & logs
sandstone & shale
sandstone with thin strips of shale
sandstone
shale
sandstone
limestone
sandstone
MW5
849.2
sandy clay
sandy shale
sandstone
shale
sandstone
shale
sandstone with thin strips of shale
sandstone
sandstone with coal
sandstone & limestone
sandstone
sandstone with strips of coal
crevices
sandstone
sandstone & shale
sandstone
sandstone with thin strips of shale
sandstone & shale
sandstone with strips of shale
MW3
868.4
refuse
sandstone & shale
sandstone
sandstone with thin strips of coal
sandstone & shale
sandstone
sandstone & shale
sandstone
shale
sandstone
MW2
879.9
refuse
sandstone & shale
sandstone
sandstone with stripe of shale
sandstone & shale
sandstone
shale
sandstone
limestone & sandstone
sandstone & shale
sandstone
MW1
873.0
refuse
shaley sandstone
sandstone & shale
sandstone with thin stripe of shale
sandstone & shale
sandstone
sandstone & shale
sandstone
shale
sandstone & shale
sandstone
sandstone & shale
sandstone
* Maximum contamination depth from geophysical logs
● Maximum contamination depth from water sample analysis
Static water level

FIGURE 2-1

identify the depths of change in formations. Resistivity logs can also be used to aid in the determination of depth of leachate contamination because the formation resistivities observed are also a function of the conductivity of the formation fluid. High levels of chlorides and total dissolved solids in the formation water increase its conductivity and thus a lower overall resistivity is observed. When this occurs, without a corresponding correlation in the driller's formation log or gamma-ray intensity log, leachate contamination can be inferred.

2.1 Monitor Well No. 1 Site

Monitor Well No. 1 (MW 1) is located in the southern portion of the landfill as shown in Exhibit A. The well was cased to a depth of 53.5 feet below ground level (bgl). The driller recorded refuse to a depth of 41 feet bgl. Problems with lost drilling fluid circulation were also experienced while drilling through this interval, verifying the existence of the refuse material. Bedrock material was encountered directly below the refuse material. The static water level for the 53.5 - 73-foot sampling interval was found to be 30.9 feet bgl, illustrating that at this site refuse material was deposited below the groundwater level.

Table 1 in Appendix I lists the sampling intervals at this site. As shown by the static water level elevations for this monitor well, there is a considerable head difference between the 53.5-73-foot interval and the underlying intervals tested. This abrupt change in static water level indicates that the first sampling interval is a perched water table with an underlying impermeable strata. The borehole geophysical logs (Appendix VI, Monitor Well No. 1) show the impermeable strata to be a shale strata in the 68 to 77-foot interval. Above this interval the material is shaly sandstone which normally has a relatively low permeability.

The resistivity logs and the analytical results from the water samples indicate that there is no noticeable leachate contamination to the Saginaw Formation at this location. The impermeable material near the bedrock surface and the fact that the general groundwater gradient for the Saginaw Formation, in the vicinity of the landfill, is to the north account for this lack of contamination. The general direction of the groundwater flow in the Saginaw Formation will be addressed later in this report.

2.2 Monitor Well No. 2 Site

Monitor Well No. 2 (MW 2) is located approximately in the center of the landfill (see Exhibit A). The well was cased to a depth of 52.5 feet bgl. The driller recorded refuse material to a depth of 42 feet. Again lost drilling fluid circulation confirmed the existence of refuse material. Bedrock material was encountered directly below the refuse material. The static water level, for the upper interval tested, was found to be 44.3 feet bgl, demonstrating that refuse material was deposited slightly above the water level at this location.

Table 2 in Appendix I lists the sampling intervals at this site. The 70 - 80-foot, and 80 - 90-foot, intervals show somewhat higher static water level elevations than the intervals below, indicating a significant downward potential for leachate movement. An accurate static water level for the 52.5 - 70-foot interval was not determined because of slow recovery after the drilling and sampling processes. The static water level elevations from 90 feet - 170 feet exhibit a general downward potential.

The resistivity logs indicate that leachate contamination has reached the 90-foot depth (see Appendix VI). Water sample analyses show high chlorides to 100 feet and high total dissolved solids (TDS) to 120 feet, indicating leachate may have reached the 120-foot depth at this site. The high TDS for the 150 - 160-foot interval are only slightly above recommended maximum levels, and are probably naturally occurring. The depth of contamination as indicated by the resistivity logs and the water analyses are shown on the profile figure in Appendix VII. The static water levels shown are for the first interval sampled.

After the completion of the geophysical logging, a temporary seal was placed in the well, at the 102-foot depth, to prevent additional downward movement of contaminants in the open borehole.

2.3 Monitor Well No. 3 Site

Monitor Well No. 3(MW3) is located in the northern portion of the landfill. This well is located in an area where sludge has been dumped on the ground surface. This well was cased to be a depth of 40.5 feet bgl. Refuse was encountered to 31 feet bgl, and lost drilling fluid circulation again confirmed this. Bedrock material was encountered directly below the refuse material. The static water level for the upper interval was found to be 33.8 feet bgl, indicating that refuse material was deposited slightly above the water level at this location.

The static water level elevations and the sampling intervals at this site are listed in Table 3 of Appendix I. The static water level elevation difference, between the 40.5 - 58-foot interval and the intervals below, indicate a significant downward potential for leachate movement. There is a general downward groundwater potential for the 58 - 158-foot interval.

The depth of leachate contamination, as shown by the resistivity logs (see Appendix VI, Well 3), is to 75 feet bgl. The water sample analyses indicate that the contaminant migration has reached the 98-foot depth, with an additional contaminated interval between 108 and 128 feet bgl. This discontinuity in the water sample analytical results can be explained by the geophysical logs which show shaly intervals between 82 and 92 feet and 100 and 108 feet. These shaly layers have apparently arrested the vertical migration of contaminants locally. However, horizontal migration of leachate appears to be occurring below the shaly interval from 100 - 108 feet. Some leakage may have occurred from above from the packer setting in the 88 - 98-foot interval, causing this interval to yield contaminated water analysis results.

A temporary seal was placed at the 104-foot depth in this well to prevent additional downward movement of contaminants in the open borehole.

2.4 Monitor Well No. 4 Site

Monitor Well No. 4 (MW 4) is located just north of the landfilled area. The well was cased to a depth of 34 feet bgl. Bedrock material was encountered at 21 feet bgl. Table 4 in Appendix I lists the sampling intervals and resulting static water level elevations at this site. There is a significant downward groundwater potential between the 34 - 60-foot interval and the underlying formation.

The resistivity logs (see Appendix VI, Well 4), indicate that leachate contamination has reached the 95-foot depth. Chloride analyses of the water samples indicate the depth of contamination is 110 feet. This is also confirmed by high TDS results. The TDS results for the 110 - 140-foot intervals may be indicative of natural background content as they, relatively, are only slightly above the recommended limits, and there is little chloride present.

A temporary seal was placed at the 95-foot depth to prevent downward movement of contaminants in the open borehole.

2.5 Monitor Well Site No. 5

Monitor Well No. 5 (MW 5) is located northwest of the landfill, outside of the landfilled area (see Exhibit A). The well was cased to a depth of 19.5 feet bgl. Bedrock material was first encountered at a depth of nine feet bgl. Table 5 in Appendix I lists the intervals sampled at this location. The static water level elevations show a general downward gradient for groundwater movement.

The resistivity logs (see Appendix VI, Well 5), indicate leachate contamination to the 65-foot depth, and also in the 95 to 110-foot interval. The water sample analyses show contamination is present to at least the 119-foot depth. A noticeable decrease in contamination level can be seen for the 89 - 99-foot and 99 - 109-foot intervals. Apparently the change in contamination level, at various depths at this site, is due to more rapid horizontal flow in zones of higher permeability from the landfill to the Monitor Well No. 5 site.

A temporary seal was placed at the 60-foot depth in an attempt to minimize contamination from the upper portion of the open borehole.

3.0 DATA ASSESSMENT

3.1 Direction of Groundwater Movement

One of the purposes for the Phase II study was to verify the horizontal direction of groundwater movement in the Saginaw Formation in the vicinity of the Aurelius Road Landfill. Although the general configuration of the five monitor well locations does not allow for a precise determination of groundwater movement, the static water level elevations collected during the drilling and sampling processes do provide the data needed to determine a general direction. This data shows that the groundwater flow is generally in a north-northwesterly direction. This correlates closely with the groundwater modelling done by the Lansing Board of Water and Light, in September 1978, and the Phase I investigation.

The groundwater gradient for the 790 to 800-foot elevation interval was calculated to be approximately 6.1×10^{-4} FT/FT. For the 710 to 720-foot elevation interval, the gradient was found to be approximately 1.5×10^{-3} FT/FT.

3.2 Estimate of Volume of Leachate Entering Sycamore Creek

The Phase I investigation concluded that the direction of groundwater movement through the drift materials was toward Sycamore Creek. The volume of leachate entering Sycamore Creek can be calculated using the following relationship:

$Q = Til$ and $T = Km$

which leads to

$Q = Kmil$

where, Q = flow rate in gpd

T = transmissivity in gpd/ft

K = hydraulic conductivity in gpd/ft^2

i = groundwater gradient in ft/ft

l = discharge length perpendicular to i

m = saturated thickness in feet

$i = 1.9 \times 10^{-3}$ ft/ft (from previous data and calculations; report of 4/19/79)

k = lab and experience values (from 4/19/79 report)

K_{avg} = 126 gpd/ft^2

with experience factor of 3 = 378 gpd/ft^2

with experience factor of 5 = 630 gpd/ft^2

K_{median} = 98 gpd/ft

with experience factor of 3 = 294 gpd/ft^2

with experience factor of 5 = 490 gpd/ft^2

Let it be noted that the K values used should include corrections for that portion which includes Sandstone (K_{avg} = 3.3 gpd/ft^2 and K_{median} = 0.29 gpd/ft^2 from lab tests in 4/19/79 report). However, we will assume that weathering and fracturing will have yielded overall K values for bedrock formations equal to the above drift material values.

l = length along Sycamore Creek perpendicular to the direction of groundwater flow = 3000'

m = saturated thickness 10 feet into sandstone at B-6 (OW-4) m = 16' -1.24' = 14.76'

The range of Q into Sycamore Creek would be:

Q_{min} = Kmil - 98 gpd/ft x 14.76 ft x 1.9 x 10^{-3} ft/ft x 3000' = 8240 gpd = 5.7 gpm

Q_{max} = 630 gpd/ft x 14.76 ft x 1.9 x 10^{-3} ft/ft x 3000'

= 53,000 gpd = 36.8 gpm

Therefore, the quantity of leachate entering Sycamore Creek is estimated to be between 5.7 and 36.8 gallons per minute.

4.0 DISCUSSION OF LEACHATE MIGRATION

In order to address the impact of the Aurelius Road Landfill on the groundwater environment, it is necessary to establish a standard for comparison. A review of the directions of groundwater flow, locations of wells and chemical analyses of these wells indicates a highly variable groundwater quality in the landfill area. Chemical analysis for onsite wells, on private wells and city wells are tabulated in Appendices III and IV. A summary of the chemical analyses of the OW-series wells is included in Appendix VIII. A plan of the landfill is included as drawing no. 1 of Exhibit A. However, it is felt that a background range of groundwater quality is typified by Wells OW9 and 11-13 listed in Table 4-1. These wells were selected as they are upgradient from the fill area and would not have been influenced by the landfill.

It is interesting to note that Well OW9 has concentrations of iron and lead above levels recommended for drinking water quality. While the iron concentrations, 0.27 mg/l to 3.9 mg/l are not surprising, the lead concentrations, 0.04 mg/l to 0.47 mg/l, are anomalous. However, lead concentrations as high as 0.30 to 1.0 mg/l have been found in "uncontaminated" wells on the DuPage County Landfill in Illinois[1], and in "uncontaminated" wells in Northern Michigan.

Applying the above standard of comparison to the chemical analyses of wells in the area results in the identification of contamination at the following locations:

1. OW1
2. OW5
3. OW7
4. OW8
5. MW2
6. MW3
7. MW4
8. MW5

A summary of the most contaminated sample obtained from each of these wells is presented in Table 4-2.

Chemical analyses of the above wells showed elevated concentrations of chlorides, sulfates and total dissolved solids above the background levels previously established. Additionally, contamination is indicated at two private wells to the west of the landfill by the presence of the above mentioned parameters. The wells in question are located at the Granger Company, well log no. 3-3, and the 84 Lumber Company, well log no. 11-15. The wells previously mentioned indicate quite clearly the horizontal extent of leachate migration.

The vertical extent of the leachate migration is illustrated in the profile in Figure 2-1 and in Appendix VII. The vertical extent varies from no contamination at well MW1 to a maximum depth of elevation 730.0 at well MW5. The vertical extent of the leachate migration generally tends to increase in the north-northwesterly direction from well MW1.

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[1] Hydrogeology of Solid Waste Disposal Sites in Northeastern Illinois, G. M. Hughes, R. A. Landon, R.N. Farvolden. USEPA Report SW-12d.

TABLE 4-1

PROPOSED BACKGROUND GROUNDWATER QUALITY RANGE

Parameter	Limit	
	High	Low
C.O.D. , mg/l	27.	1.
Chloride, mg/l	79.	16.
Sulphate, mg/l	57.7	7.4
T.D.S. , mg/l	496.	293.
pH	10.0	7.7
Iron , mg/l	3.9	.27
Lead , mg/l	0.47	0.04

The above range of values was taken from water analysis of wells OW9 and 11-13.

TABLE 4-2

CHEMICAL ANALYSIS OF WELLS INDICATING CONTAMINATION

Well No.:	OW1	OW5	OW7	OW8	MW2	MW3	MW4	MW5	USEPA Maximum Contamination Levels[2]
Parameter									
Chloride mg/l	520	237	631	143	780	840	630	540	250
Sulfate mg/l	80	235	223	200	160	200	150	470	250
Nitrate mg/l	.23	0.17	ND	0.11	0.36	0.84	0.29	0.96	10
T.D.S. mg/l	2800	2400	2362	1200	2400	3600	2400	2700	500
pH	8.4	9.5	9.6	10.0	7.8	8.2	7.9	8.2	6.5 - 8.5
Iron mg/l	10.0	7.7	9.1	12.0	52	125	7.6	28	0.3
PCB (Aroclor)	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	-
Lead mg/l	.07	.03	.08	0.5	.01	.02	.14	.03	0.05
C.O.D. mg/l	130	-	-	-	290	320	-	-	-

The above analyses represent the highest concentration levels observed

ND = None Detected; LT = Less Than

[1]PCB - Aroclor 1242 - Less Than .02 ppb
- Aroclor 1254 - Less Than .05 ppb
- Aroclor 1260 - Less Than .06 ppb

[2]Published in the Federal Register, September 13, 1979

Based on the previous discussions, it has now been established that leachate is being discharged from the landfill and is migrating in the drift materials eastward and is discharging into Sycamore Creek. Further, leachate is entering the flow system in the Saginaw Formation and is migrating in a north-northwesterly direction and has migrated from the boundaries of the landfill. Based on hydraulic conductivity and transmissivity values known to apply to the Saginaw Formation, the rate of migration of contaminated groundwater from the site is estimated to be in the range of 15 to 30 ft./yr. Due to pumping from private wells west of the site, leachate has migrated, locally, to those private wells.

5.0 NEED FOR CORRECTIVE ACTION

The need for corrective action at the Aurelius Road Landfill is based upon recently promulgated regulations under the Solid Waste Disposal Act, Resource Conservation and Recovery Act and the Clean Water Act. Federal Regulations 40 CFR Part 256.25 recommends that "Inactive facilities that continue to produce adverse health or environmental effects should be evaluated according to the criteria". The referenced criteria are described under 40 CFR Part 257.3-41(a), state "A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary.." and further requires that the contaminant concentration levels not exceed the values listed in Table V-1. These regulations were published in the Federal Register on July 31 and September 13, 1979. In addition, rule no. 323.2205(3) of Public Act 245 states "no materials at concentrations which exceed maximum contaminant levels. . . shall be discharged to groundwaters in useable aquifers even in those cases where local background groundwater levels for those materials exceed the specified levels".

Comparison of the chemical analyses for the wells listed in section 4.0 with Table V-1 shows that the maximum contaminant levels have been exceeded in chlorides, total dissolved solids, iron and sulfates. It is clear that the Aurelius Road Landfill is in violation of the above referenced regulations.

However, in determining the need for corrective action, it is essential to analyse the impact of the landfill on the environment. Sycamore Creek was sampled upgradient of the fill area adjacent to the fill area and at the final effluent of the Mason WWTP. These analyses are listed in Appendix III. No discernible impact on the quality of the stream is evident. The quality of the leachate flowing in the drift materials is expected to be similar to that listed in Table V-1. The expected discharge of contaminants to Sycamore Creek by the flow in the drift materials and the Mason WWTP is listed below:

Parameter	Drift flow[1] (lbs/day)	Mason WWTP[2] Final Effluent (lbs/day)
Chlorides	229	1000
Sulfates	35	-
Nitrates	0.1	10
Iron	4.4	-
BOD	-	100
COD	74	-

[1]Flow = .053 MGD from 37 gpm in Section 3.2

[2]From 208 Areawide Study, 1981 projected discharges with completion of Mason's Advanced Wastewater Treatment Plant

Based upon the above, the flow in the drift materials contributes substantially less pollutant load to Sycamore Creek than the Mason WWTP and it could be concluded that corrective action is not required.

However, the contaminated flow in the Saginaw Formation poses a more serious problem. Table V-1 lists the expected concentrations of pollutants in the Saginaw Formation flow. As this flow is migrating north to the City wells and has contaminated private wells off the landfill property, corrective action is necessary.

It must be stated that it is possible that MDNR would require the City to install collection facilities for the drift flow system, between the landfill and Sycamore Creek, and treat the flow collected prior to discharge. It is the position of SEG that this is not a necessary course of action.

6.0 REMEDIAL MEASURES

Based on the discussions in Chapter 5.0, a need for corrective action has been demonstrated.

Any remedial activities designed to eliminate or retard existing contamination of groundwater resulting from the Aurelius Road Landfill must address the following items:

1. Minimize infiltration through the landfill surface to prevent continued leachate development.

2. Minimize lateral inflow of groundwater through the landfill to prevent continued leachate development.

3. Intercept and recover contaminated groundwater.

4. Treatment of contaminated groundwater and subsequent disposal.

6.1 Surface Infiltration

Infiltration into the landfill can be minimized by grading those flat areas of the landfill to a minimum slope of 2% to encourage surface runoff. To accomplish this grading it would be necessary to import soil to build up the landfill surface. Infiltration can be further reduced by placing a clay cap over the landfill surface. Where slopes exceed 10%, surface runoff is relatively high and would not be materially increased by the placement of the clay cap. However, some localized work would be required on these slopes to repair erosion gullies.

An investigation to preliminarily locate a source of clay was conducted by Beery and Associates, Okemos, Michigan. This report is included in Appendix IX. As was noted in the report, field studies would be required to verify that the quantities required are available. These studies should concentrate initially on the city owned property east of the landfill.

Preliminary grading plans were evaluated to determine the quantity of clay materials required to provide a drainable surface on the landfill. These evaluations showed that approximately 240,000 C.Y. of clay is required. On the city owned 60 acre property east of the fill area, this would represent an excavation over the sixty acres of approximately 2 1/2 feet. If only 30 acres were available clay, approximately 5' would have to be excavated over the 30 acres.

This method of "capping" results in the peripheral edges of the landfill having sandy cover material which would allow for venting of gas from the fill area. However, should MDNR require the entire fill area to be capped with two (2) feet of clay, an additional 113,000 c.y. of clay would be required, and the problem of venting the fill to prevent gas migration must be addressed.

6.2 Groundwater Inflow

Lateral inflow of groundwater can be reduced or eliminated by placing an upgradient open trench or perforated pipe to intercept groundwater flowing in the drift materials to the landfill. This trench or pipe could be installed

on the bedrock surface, which is higher in elevation than the water level in Sycamore Creek (see Exhibit A - drawing no. 2). This would lower the water table within the fill area and reduce the generation of leachate. The quantity of leachate which would continue to be generated would be expected to have a minor impact on the groundwaters.

The groundwater gradient in the area of the interceptor trench would be expected to cause some flow from the landfill into the trench. It is anticipated that for a period of time it would be necessary to provide some type of treatment on this flow prior to a discharge to Sycamore Creek. However, in time the quality should be sufficiently improved to allow a direct gravity flow discharge to the creek.

6.3 Interception and Recovery

As was discussed in Section 5.0, the groundwater flowing in the drift materials would not require corrective action. However, the groundwater flowing in the Saginaw Formation which does require corrective action could be removed by using deep pumping purge wells. It would be necessary to conduct field pumping tests on the existing wells to determine the areal extent of influence of the well(s), flow rates, groundwater quality, and the number of wells to be utilized. Pumping this well(s) would be carried out to develop a cone of influence in the ground such that migration of contaminated groundwater from the site would be precluded. In order to capture the contaminated water that has moved off site, additional observation wells will have to be drilled west and north of the site and purge wells may have to be located off site.

Following the development of this cone of influence, it would be necessary to pump the wells intermittently, but sufficiently long to maintain the hydraulic gradient towards the purge well(s) at the site. It is anticipated that the quality of groundwater extracted by these wells would exhibit concentrations less than those listed in Table V-1 as a result of dilution.

Following the recovery of this contaminated groundwater, it is necessary to determine a method of disposal. Due to the relatively high concentrations of contaminants, it is expected that for some period of time, treatment would be required prior to a stream discharge or a land application such as spray irrigation. Such discharges require a NPDES permit.

An alternative to on site treatment would be a discharge to the City sanitary sewer system. An existing 10" line is located at the intersection of Aurelius Rd. and Enterprise Rd. Due to the effluent requirements of the City Sewer Use Ordinance, and available flow capacity in the sewerage system, an assessment of the impact of purge well flow on the City's treatment and sewer system would be required.

7.0 CONCLUSIONS

1. Leachate from the Aurelius Road Landfill contains contaminants flowing to the groundwater in excess of background quality and also in excess of USEPA and Michigan maximum contaminant levels and as such is adversely impacting the drinking water serving the immediate area.

2. The groundwater flow system in the drift materials is discharging to Sycamore Creek at the rate of 6 gpm to 37 gpm.

3. The contamination from the landfill has extended to an elevation of approximately 730.00, approximately 120 feet below the surface generally north and northwest of the site. The minimum lateral extent of this contamination is shown on Exhibit A, Drawing 1.

4. The contamination has migrated from the property and has affected private wells to the west of the landfill.

5. The contamination should not only be precluded from future migration from the site, but existing contamination should be recovered and disposed of in an environmentally acceptable method.

6. Attempts should be made to retard future formation of new leachate.

7. Chemical analysis of the wells on the landfill indicate that PCB's are not detectable. While lead concentrations above maximum contaminant levels (.05 mg/l) were detected, no conclusion can be drawn due to high background levels of lead in "noncontaminated" wells in the area.

8.0 RECOMMENDATIONS

1. A meeting should be held with Mr. Rod Mosier, MDNR to present this report and obtain MDNR concurrence with the proposed course of action.

2. The City should, using Board of Water & Light forces, install a municipal water main on Aurelius Road as soon as possible.

3. The City should enter into a multi-phase engineering contract, the scope of which would be as outlined in the following. These activities are shown graphically on Figure 8.1.

Phase I

A. In order to verify that hazardous pollutants are not present at the Aurelius Road Landfill, run three (3) priority pollutant scans on groundwater samples.

B. The depth of the existing soil cover over the landfill should be determined by field investigations. These field investigations should also focus on the city owned woodyard east of the landfill to verify the presence of adequate quantities of clay material to be utilized as the final cover.

C. Perform a groundwater modelling program to define the optimal method to not only minimize the generation of new leachate but also recover that which is currently in the aquifer. The modelling will include the definition of an optimal purge well system.

Phase II

The Phase II portion of the contract would include the following items:

A. Design of a two foot clay cap and preparation of the final grading plan.

B. Final design of the purge well system.

C. Design of a groundwater monitoring program to verify the effectiveness of the proposed remedial activities.

D. Preparation of contract bidding documents.

Phase III

The Phase III portion of the contract would include the following:

A. Assistance in the taking of bids.

B. Supervision of construction activities.

Phase IV

The Phase IV portion of the contract would include the following:

A. Engineering certification of all construction activities.

B. Implement monitoring program.

CITY OF LANSING
AURELIUS ROAD LANDFILL

PRELIMINARY CONSTRUCTION SCHEDULE

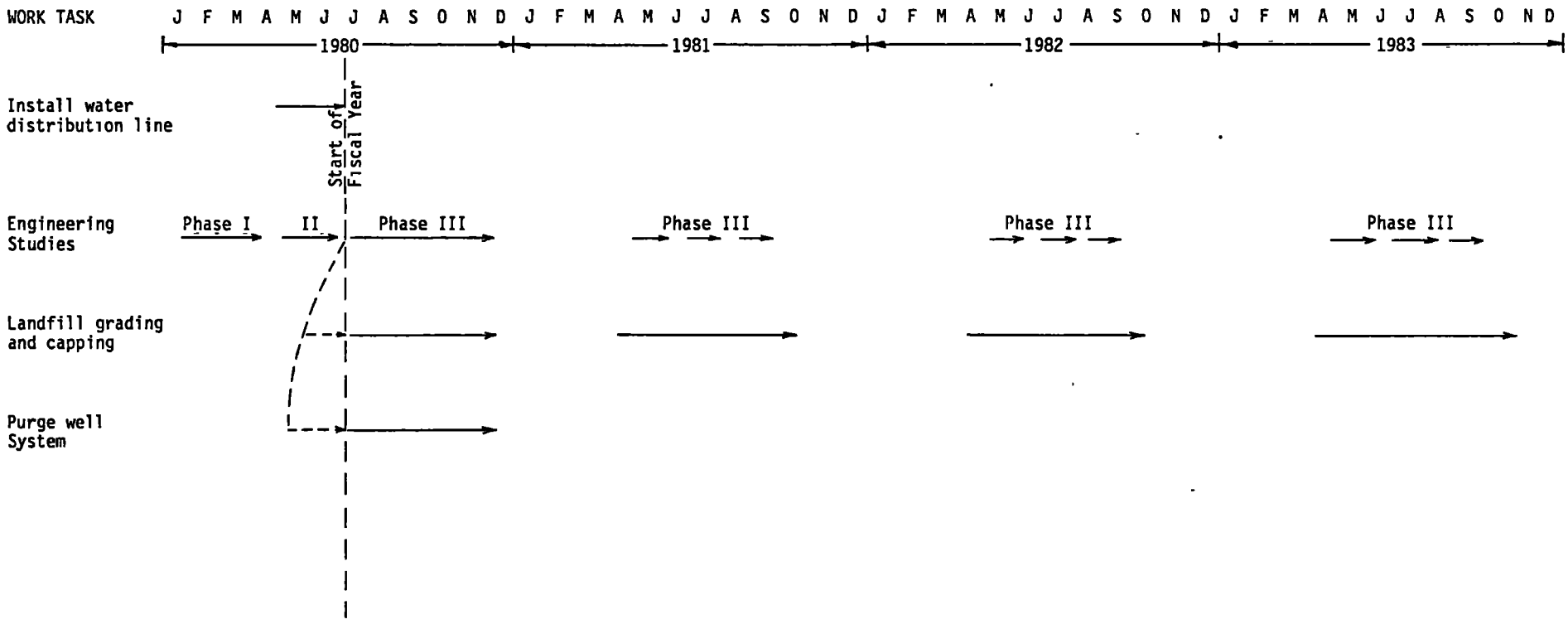

FIGURE 8-1

APPENDIX I

DATA ON MONITORING WELLS

TABLE 1

DATA TABLE FOR MONITOR WELL NO. 1

AURELIUS ROAD LANDFILL

SECTIONS 2 AND 11 , DELHI TOWNSHIP

INGHAM COUNTY , MICHIGAN

GROUND LEVEL ELEVATION = 873.0'
TOP OF CASING (TOC) ELEVATION = 874.36'

SAMPLE NO.	INTERVAL BGL	ELEVATION	STATIC WATER LEVEL ELEVATION	PUMPING TIME BEFORE SAMPLING	WATER QUALITY PARAMETERS ABOVE EPA RECOMMENDED OR ENFORCEABLE LIMITS
1	53.5' - 73'	819.5' - 800'	842.13'	58 MIN	Fe
2	73' - 83'	800' - 790'	831.78'	27 MIN	Fe
3	83' - 93'	790' - 780'	831.40'	38 MIN	TDS, Fe
4	93' - 103'	780' - 770'	831.40'	28 MIN	
5	103' - 113'	770' - 760'	831.38'	23 MIN	
6	113' - 123'	760' - 750'	831.40'	22 MIN	Fe
7	123' - 133'	750' - 740'	831.49'	22 MIN	
8	133' - 143'	740' - 730'	831.40'	23 MIN	
9	143' - 153'	730' - 720'	831.42'	21 MIN	Fe
10	153' - 163'	720' - 710'	831.40'	21 MIN	TDS, Fe

TABLE 2

DATA TABLE FOR MONITOR WELL NO. 2

AURELIUS ROAD LANDFILL

SECTIONS 2 AND 11, DELHI TOWNSHIP

INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION = 879.9'
TOP OF CASING (TOC) ELEVATION = 881.60'

SAMPLE NO.	INTERVAL BGL	ELEVATION	STATIC WATER LEVEL ELEVATION	PUMPING TIME BEFORE SAMPLING	WATER QUALITY PARAMETERS ABOVE EPA RECOMMENDED OR ENFORCEABLE LIMITS
1	52.5'- 70'	827.5'- 810'	N.D. - RECOVERING	90 MIN	Cl, TDS, Fe
2	70' - 80'	810'- 800'	834.68'	31 MIN	Cl, TDS, Fe
3	80'- 90'	800'-790'	834.27'	25 MIN	Cl, TDS, Fe
4	90'- 100'	790'-780'	831.77'	23 MIN	Cl, TDS, Fe
5	100'- 110'	780'-770'	831.79'	22 MIN	TDS, Fe
6	110'- 120'	770'-760'	831.93'	20 MIN	TDS, pH, Fe
7	120'- 130'	760'-750'	831.31'	23 MIN	Fe
8	130'-140'	750'-740'	831.31'	24 MIN	Fe
9	140'-150'	740'-730'	830.93'	29 MIN	Fe
10	150'-160'	730'-720'	830.83'	23 MIN	TDS, Fe
11	160'-170'	720'-710'	830.98'	22 MIN	Fe

TABLE 3

DATA TABLE FOR MONITOR WELL NO. 3

AURELIUS ROAD LANDFILL

SECTIONS 2 AND 11, DELHI TOWNSHIP

INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION = 868.4'
TOP OF CASING (TOC) ELEVATION = 869.92'

SAMPLE NO.	INTERVAL BGL	ELEVATION	STATIC WATER LEVEL ELEVATION	PUMPING TIME BEFORE SAMPLING	WATER QUALITY PARAMETERS ABOVE EPA RECOMMENDED OR ENFORCEABLE LIMITS
1	40.5' - 58'	828' - 810'	834.61'	37 MIN	Cl, TDS, Fe
2	58' - 68'	810' - 800'	830.96'	75 MIN	Cl, TDS, Fe
3	68' - 78'	800' - 790'	830.59'	24 MIN	Cl, TDS, Fe
4	78' - 88'	790' - 780'	829.09'	20 MIN	Cl, TDS, Fe
5	88' - 98'	780' - 770'	830.44'	21 MIN	Cl, TDS, Fe
6	98' - 108'	770' - 760'	N.D. - RECOVERING	24 MIN	Fe
7	108' - 118'	760' - 750'	828.63'	23 MIN	TDS, Fe
8	118' - 128'	750' - 740'	829.80'	22 MIN	Cl, TDS, Fe
9	128' - 138'	740' - 730'	828.61'	23 MIN	TDS, Fe
10	138' - 148'	730' - 720'	829.80'	21 MIN	Fe
11	148' - 158'	720' - 710'	829.00'	22 MIN	Fe

TABLE 4

DATA TABLE FOR MONITOR WELL NO. 6

AURELIUS ROAD LANDFILL

SECTIONS 2 AND 11, DELHI TOWNSHIP

INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION = 845.9'
TOP OF CASING (TOC) ELEVATION = 847.81'

SAMPLE NO.	INTERVAL BGL	ELEVATION	STATIC WATER LEVEL ELEVATION	PUMPING TIME BEFORE SAMPLING	WATER QUALITY PARAMETERS ABOVE EPA RECOMMENDED OR ENFORCEABLE LIMITS
1	34'- 46'	812'- 798'	827.52'	18 MIN	Cl, TDS, Fe
2	50'- 60'	796'- 786'	828.31'	20 MIN	Cl, TDS, Fe, Pb
3	60'- 70'	786'- 776'	823.60'	22 MIN	Cl, TDS, Fe
4	70'- 80'	776'- 766'	823.23'	26 MIN	Cl, TDS, Fe
5	80'- 90'	766'- 756'	823.52'	21 MIN	Cl, TDS
6	90'- 100'	756'- 746'	823.56'	21 MIN	Cl, TDS, Fe
7	100'- 110'	746'- 736'	823.91'	22 MIN	Cl, TDS
8	110'- 120'	736'- 726'	824.46'	21 MIN	TDS, Fe
9	120'- 130'	726'- 716'	824.31'	24 MIN	TDS
10	130'- 140'	716'- 706'	824.44'	22 MIN	TDS

TABLE 5

DATA TABLE FOR MONITOR WELL NO. 5

AURELIUS ROAD LANDFILL

SECTIONS 2 AND 11, DELHI TOWNSHIP

INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION = 849.2'
TOP OF CASING (TOC) ELEVATION = 850.72'

SAMPLE NO.	INTERVAL BGL	ELEVATION	STATIC WATER LEVEL ELEVATION	PUMPING TIME BEFORE SAMPLING	WATER QUALITY PARAMETERS ABOVE EPA RECOMMENDED OR ENFORCEABLE LIMITS
1	19.5'- 39'	829.5' - 810'	831.22'	23 MIN	Cl, TDS, Fe
2	39'- 49'	810' - 800'	829.99'	21 MIN	TDS, Fe
3	49' - 59'	800' - 790'	830.49'	21 MIN	SO_4, TDS, Fe
4	59'- 69'	790'- 780'	830.45'	35 MIN	SO_4, TDS, Fe
5	69'- 79'	780'- 770'	830.47'	34 MIN	SO_4, TDS, Fe
6	79'- 89'	770'- 760'	829.43'	21 MIN	SO_4, TDS, Fe
7	89'- 99'	760'- 750'	828.62'	23 MIN	TDS, Fe
8	99'- 109'	750'- 740'	827.74'	23 MIN	TDS, Fe
9	109'- 119'	740'- 730'	N.D. - RECOVERING	27 MIN	SO_4, TDS, Fe
10	119' - 129'	730'- 720'	827.60'	29 MIN	TDS, Fe
11	129'- 139'	720'- 710'	N.D. - RECOVERING	39 MIN	TDS, Fe

APPENDIX II

CHEMICAL ANALYSES OF MONITORING WELLS MW1 to MW5

TABLE II-1

August 31, 1979

Analytical results for samples collected from Well #1 at Aurelius Road landfill by Keck Consulting Services, Inc.

SEG No.	91139	91140	91141	91142	91143	91144	91145	91146	91147	91148
Tag:	Sample 1 53.5'-70' 8/15/79	Sample 2 73'-83' 8/15/79	Sample 3 83'-93' 8/15/79	Sample 4 93'-103' 8/16/79	Sample 5 103'-113' 8/16/79	Sample 6 113'-123' 8/16/79	Sample 7 123'-133' 8/16/79	Sample 8 133'-143' 8/16/79	Sample 9 143'-153' 8/16/79	Sample 10 153'-163' 8/16/79
Chloride mg/l	18	4	LT1	LT1	LT1	2	LT1	LT1	LT1	LT1
Sulfate mg/l	28	56	140	28	17	35	16	8.6	14	180
Nitrate mg/l	1.2	ND	0.75	0.25	0.17	0.02	ND	ND	ND	ND
Total dissolved solids mg/l	320	220	560	260	240	230	380	360	350	700
pH	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Iron mg/l	7.1	2.3	9.4	0.3	0.3	0.4	0.3	0.3	0.4	13
Lead mg/l	ND[4]	ND[4]	0.04	0.02	ND[4]	ND[4]	ND[4]	ND[4]	ND[4]	ND[4]
PCB, ppb (Aroclor)	Sample Lost	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

LT = Less Than

ND = None Detected

ND[4] = Less Than 0.001 mg/l

ND[1] = Non detectable levels for Aroclor are as follows: 1242 - LT 0.020 ppb; 1254 - LT 0.050 ppb; 1260 - LT 0.060 ppb.

TABLE II-1
(Continued)

August 31, 1979

Analytical results for samples collected from Well #2 at Aurelius Road landfill by Keck Consulting Services, Inc.

SEG No.	91092	91093	91094	91124	91125	91126	91127	91128	91129	91130	91131
Tag:	Sample 1 52.5'-70' 8/13/79	Sample 2 70'-80' 8/13/79	Sample 3 80'-90' 8/13/79	Sample 4 90'-100' 8/14/79	Sample 5 100'-110' 8/14/79	Sample 6 110'-120' 8/14/79	Sample 7 120'-130' 8/14/79	Sample 8 130'-140' 8/14/79	Sample 9 140'-150' 8/14/79	Sample 10 150'-160' 8/14/79	Sample 11 160'-170' 8/14/79
Chloride mg/l	780	570	520	320	50	11	28	11	6	49	LT1
Sulfate mg/l	130	100	160	160	92	59	27	28	17	35	16
Nitrate mg/l	0.36	0.25	0.32	ND	ND	ND	ND	0.43	ND	0.83	1.8
Total dissolved solids mg/l	2400	2400	1800	1200	840	620	360	110	210	580	160
pH	7.8	7.0	7.0	7.7	8.3	8.6	8.3	8.2	8.3	8.5	8.4
Iron mg/l	7.0	52	49	13	3.8	5.4	0.6	1.0	0.6	1.0	1.0
Lead mg/l	ND[4]	.01	ND[4]	LT0.01	LT0.01	LT0.01	LT0.01	ND[4]	ND[4]	LT0.01	ND[4]
PCB, ppb (Aroclor)	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

LT = Less Than

ND = None Detected

ND[4] = Less Than 0.001 mg/l

ND[1] = Non detectable levels for Aroclor are as follows: 1242 - LT 0.020 ppb; 1254 - LT 0.050 ppb; 1260 - LT 0.060 ppb.

TABLE II-1
(Continued)

August 31, 1979

Analytical results for samples collected from Well #3 at Aurelius Road landfill by Keck Consulting Services, Inc.

SEG No.	91081	91082	91083	91084	91085	91086	91087	91088	91089	91090	91091
Tag:	Sample 1 40.5'-58' 8/10/79	Sample 2 58'-68' 8/10/79	Sample 3 68'-78' 8/10/79	Sample 4 78'-88' 8/10/79	Sample 5 88'-98' 8/10/79	Sample 6 98'-108' 8/10/79	Sample 7 108'-118' 8/10/79	Sample 8 118'-128' 8/10/79	Sample 9 128'-138' 8/10/79	Sample 10 138'-148' 8/10/79	Sample 11 148'-158' 8/10/79
Chloride mg/l	840	690	640	390	580	4	180	540	150	57	2
Sulfate mg/l	200	25	21	37	24	17	120	86	38	15	4
Nitrate mg/l	0.57	0.45	0.58	0.15	0.31	ND	0.84	0.66	ND	ND	0.08
Total dissolved solids mg/l	3600	2200	2200	2300	2100	190	980	1800	550	250	180
pH	7.3	6.3	6.3	7.2	6.6	8.2	7.8	7.0	7.9	7.9	8.2
Iron mg/l	55	125	112	29	68	1.3	8.7	42	5.9	4.4	0.5
Lead mg/l	LT0.01	ND[4]	ND[4]	LT0.01	ND[4]	LT0.01	0.01	ND[4]	0.02	ND[4]	ND[4]
PCB, ppb (Aroclor)	ND[1]	ND[1]	ND[1]	Sample Lost	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

LT = Less Than

ND = None Detected

ND[4] = Less Than 0.001 mg/l

ND[1] = Non detectable levels for Aroclor are as follows: 1242 - LT 0.020 ppb; 1254 - LT 0.050 ppb; 1260 - LT 0.060 ppb.

TABLE II-1
(Continued)

August 31, 1979

Analytical results for samples collected from Well #4 at Aurelius Road landfill by Keck Consulting Services, Inc.

SEG No.	91002	91003	91004	91005	91006	91007	91008	91009	91010	91011
Tag:	Sample 1 38'-48' 8/6/79	Sample 2 50'-60' 8/6/79	Sample 3 60'-70' 8/6/79	Sample 4 70'-80' 8/6/79	Sample 5 80'-90' 8/7/79	Sample 6 90'-100' 8/7/79	Sample 7 100'-110' 8/7/79	Sample 8 110'-120' 8/7/79	Sample 9 120'-130' 8/7/79	Sample 10 130'-140' 8/7/79
Chloride mg/l	630	590	570	450	500	390	440	3	32	LT1
Sulfate mg/l	130	150	150	130	120	90	100	1.9	9.5	0.62
Nitrate mg/l	0.29	0.29	0.13	0.13	0.26	0.11	0.07	ND	ND	0.03
Total dissolved solids mg/l	2300	2400	2200	2000	2100	1900	2000	630	720	670
pH	7.8	7.8	7.9	7.9	7.9	8.0	8.0	8.2	8.2	8.2
Iron mg/l	7.6	6.5	5.5	4.6	0.2	2.3	0.3	0.56	ND	0.1
Lead mg/l	ND[4]	0.14	ND[4]	ND[4]	ND[4]	LT0.01	0.01	ND[4]	LT0.01	ND[4]
PCB, ppb (Aroclor)	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

LT = Less Than

ND = None Detected

ND[4] = Less Than 0.001 mg/l

ND[1] = Non detectable levels for Aroclor are as follows: 1242 - LT 0.020 ppb; 1254 - LT 0.050 ppb; 1260 - LT 0.060 ppb.

TABLE II-1
(Continued)

August 31, 1979

Analytical results for samples collected from Well #5 at Aurelius Road landfill by Keck Consulting Services, Inc.

SEG No.	91039	91040	91041	91042	91043	91044	91045	91046	91047	91048	91049
Tag:	Sample 1 19.5'-39' 8/9/79	Sample 2 39'-49' 8/9/79	Sample 3 49'-59' 8/9/79	Sample 4 59'-69' 8/9/79	Sample 5 69'-79' 8/9/79	Sample 6 79'-89' 8/9/79	Sample 7 89'-99' 8/9/79	Sample 8 99'-109' 8/9/79	Sample 9 109'-119' 8/9/79	Sample 10 119'-129' 8/9/79	Sample 11 129'-139' 8/9/79
Chloride mg/l	540	210	42	45	26	110	42	29	87	7	15
Sulfate mg/l	120	140	470	400	270	460	76	96	420	40	60
Nitrate mg/l	ND	0.59	0.96	0.69	0.63	0.23	0.05	0.52	ND	LT0.01	0.38
Total dissolved solids mg/l	2700	1300	1700	1700	970	1600	900	1000	1700	810	970
pH	7.8	8.0	7.8	8.2	8.2	8.0	8.1	8.1	8.0	8.1	8.3
Iron mg/l	25	2.4	5.3	28	4.4	4.9	1.6	0.6	3.4	2.3	7.8
Lead mg/l	0.03	0.02	ND[4]	0.02	0.01	ND[4]	LT0.01	LT0.01	LT0.01	ND[4]	0.04
PCB, ppb (Aroclor)	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]

LT = Less Than

ND = None Detected

ND[4]= Less Than 0.001 mg/l

ND[1]= Non detectable levels for Aroclor are as follows: 1242 - LT 0.020 ppb; 1254 - LT 0.050 ppb; 1260 - LT 0.060 ppb.

APPENDIX III

CHEMICAL ANALYSES OF PHASE I WELLS

Snell Environmental Group
Engineering · Planning · Research

September 14, 1979

Analytical results for samples collected from the old test wells at Aurelius Road Landfill by Snell Environmental Group

SEG Number:	91113	91114	91115	91116
Tag:	OW1 Deep 8/14/79	OW1 Shallow 8/14/79	OW2 8/14/79	OW3 8/14/79
Chloride mg/l	520	370	85	30
Sulfate mg/l	80	71	14	46
Nitrate mg/l	0.23	0.18	ND	ND
Total Dissolved Solids mg/l	2,800	2,200	790	990
pH	7.4	7.4	9.2	8.0
Iron	2.6	10	0.91	3.6

ND = None Detected

Approved by

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Snell Environmental Group
Engineering · Planning · Research

September 14, 1979

Analytical results for samples collected from the old test wells at Aurelius Road Landfill by Snell Environmental Group

SEG Number:	91117	91118	91119	911120
Tag:	OW4 8/14/79	OW5 8/14/79	OW6 Deep 8/14/79	OW7 Deep 8/14/79
Chloride mg/l	72	220	8.3	610
Sulfate mg/l	32	124	18	75
Nitrate mg/l	ND	0.17	ND	ND
Total Dissolved Solids mg/l	1,100	2,400	770	1,800
pH	9.8	7.5	9.7	9.6
Iron	0.6	7.7	1.0	0.35

ND = None Detected

Approved by

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September 17, 1979

Analytical results for samples collected from the old test wells at Aurelius Road Landfill by Snell Environmental Group

SEG Number:	91121 91229	91122	91123 91226
Tag:	OW8 Shallow 8/14/79 8/23/79	OW9 Shallow 8/14/79	OW6 Shallow 8/14/79 8/23/79
Chloride mg/l	58	16	LT1
Sulfate mg/l	200	7.4	310
Nitrate mg/l	0.11	ND	0.07
Total Dissolved Solids mg/l	1,200	440	310
pH	10	10	10
Iron	1.4	1.0	5.3

LT = Less Than

ND = None Detected

Approved by Michael S. Snell Jr.

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September 14, 1979

Analytical results for samples collected by Snell Environmental Group along Sycamore Creek near Aurelius Road Landfill on 8/8/79

SEG Number:	91014	91015	91016
Tag:	Sycamore Creek Between OW4 and Freeway 8/8/79	Sycamore Creek upstream landfill across I96 8/8/79	Mason WWTP Final effluent 8/8/79
Chloride mg/l	59	60	320
Sulfate mg/l	63	62	76
Nitrate mg/l	.95	1.0	.37
Total Dissolved solids mg/l	440	490	990
pH	8.4	8.4	7.7
Iron	0.5	0.44	1.2

Approved by Michael Dobey

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September 17, 1979

Analytical results of samples collected by Snell Environmental Group along Sycamore Creek near Aurelius Road Landfill on 8/23/79

SEG Number:	91225	91227	91228
Tag:	WWTP Outfall 8/23/79	Sycamore Creek @ OW4 8/23/79	Sycamore Creek @ Pinetree Rd. 8/23/79
Chloride mg/l	370	76	71
Sulfate mg/l	120	70	52
Nitrate mg/l	2.4	0.81	0.47
Total Dissolved Solids mg/l	1,000	570	470
pH	7.6	8.1	8.1
Iron	.44	.26	.35

Approved by Michael D Sargent

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September 17, 1979

Analytical results for samples collected by Snell Environmental Group along Sycamore Creek near Aurelius Road Landfill on 8/8/79

SEG Number:	91288	91289	91290
Tag:	Between OW4 and OW6 9/5/79	Sycamore Creek & Pinetree Rd. 9/5/79	Final Effluent WWTP 9/5/79
Chloride mg/l	61	63	330
Sulfate mg/l	47	59	72
Nitrate mg/l	.95	.98	9.6
Total Dissolved Solids mg/l	1,200	1,100	1,400
pH	7.8	7.8	7.4
Iron	.35	.52	1.2

Approved by Michael D Sarver

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Snell Environmental Group

Engineering · Planning · Research

October 10, 1979

Analytical results for samples collected from the old test wells at Aurelius Road Landfill and along Sycamore Creek near Aurelius Road Landfill by Snell Environmental Group

SEG # and Tag	Aroclor 1242 ppb	Aroclor 1254 ppb	Aroclor 1260 ppb	Lead mg/l
#91014 Sycamore Cr. between OW 4 and Freeway 8/8/79	ND[1]	ND[2]	ND[3]	ND[4]
#91015 Sycamore Cr. upstream landfill across I-96 8/8/79	ND[1]	ND[2]	ND[3]	ND[4]
#91016 Mason WWTP final effluent 8/8/79	ND[1]	ND[2]	ND[3]	.02
#91113 OW1 Deep 8/14/79	ND[1]	ND[2]	ND[3]	LT0.01
#91114 OW1 Shallow 8/14/79	ND[1]	ND[2]	ND[3]	.03
#91115 OW2 8/14/79	ND[1]	ND[2]	ND[3]	.12
#91116 OW3 8/14/79	sample lost----------			.10
#91117 OW4 8/14/79	ND[1]	ND[2]	ND[3]	.03
#91118 OW5 8/14/79	ND[1]	ND[2]	ND[3]	.03
#91119 OW6 Deep 8/14/79	ND[1]	ND[2]	ND[3]	.26
#91120 OW7 Deep 8/14/79	ND[1]	ND[2]	ND[3]	.04
#91121 OW8 Shallow #91229 8/14/79; 8/23/79	ND[1]	ND[2]	ND[3]	.10

LT = Less Than
ND = None Detected

ppb = Parts Per Billion

[1] LT .020 ppb
[2] LT.050 ppb
[3] LT .060 ppb
[4] LT0.001 mg/l

Aprpoved by Michael G Hoegnsen

1120 May St, Lansing, Mich 48906 • Telephone (517) 374-6800 • Additional Offices in Akron • Indianapolis • Tokyo • Dacca • Amman
CABLE "SNELL" TELEX 229458

Snell Environmental Group

Engineering · Planning · Research

October 12, 1979

Analytical results for samples collected from the old test wells at Aurelius Road Landfill and along Sycamore Creek near Aurelius Road Landfill by Snell Environmental Group

SEG # and Tag	Aroclor 1242 ppb	Aroclor 1254 ppb	Aroclor 1260 ppb	Lead mg/l
#91122 OW 9 Shallow 8/14/79	ND[1]	ND[2]	ND[3]	.21
#91123 OW6 Shallow #91226 8/14/79 and 8/23/79	ND[1]	ND[2]	ND[3]	.51
#91225 WWTP Outfall 8/23/79	ND[1]	ND[2]	ND[3]	ND[4]
#91227 Sycamore Cr. @ OW4 8/23/79	ND[1]	ND[2]	ND[3]	ND[4]
#91228 Sycamore Creek at Pinetree Road 8/23/79	ND[5]	ND6	ND[7]	ND[4]
#91288 Btw. Sycamore Cr. OW4 and OW6 9/5/79	ND[1]	ND[2]	ND[3]	ND[4]
#91289 Sycamore Cr. & Pinetree Rd. 9/5/79	ND[5]	ND[6]	ND[7]	.04
#91290 Final effluent WWTP 9/5/79	ND[1]	ND[2]	ND[3]	.01

ND = None Detected

[1]LT .020 ppb
[2]LT .050 ppb
[3]LT .060 ppb
[4]LT 0.001 mg/l
[5]LT 0.077 ppb
[6]LT 0.11 ppb
[7]LT 0.21 ppb

Approved by Michael V. Gregory, Jr.

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APPENDIX IV

CHEMICAL ANALYSIS OF PRIVATE WELLS AND CITY WELLS

WILLIAM G. MILLIKEN, Governor

MAURICE S. REIZEN, M.D., Director

STATE OF MICHIGAN
DEPARTMENT OF PUBLIC HEALTH
3500 N LOGAN, P.O BOX 30035, LANSING, MICHIGAN 48909

June 11, 1979

Snell Environmental Group
1120 May Street
Lansing, Michigan 48906

Attention: Mr. Peter Cole

Subject: Water Sampling - Aurelius Road Landfill
City of Lansing

Gentlemen:

Enclosed please find a correction of the Chart of City Well Analyses Results - Michigan Department of Public Health Laboratory.

City Well No. 60-6 was not sampled. In addition, results are now listed for Total Organic Carbons (T.O.C.). Also, please make a change in the chart of results of the Ingham County Health Department for Granger Company. Sulfate (SO_4) results of October 19, 1978 were 71.7 not 71.1 as listed.

Sample results are not yet available for the rare metals.

If further questions arise please do not hesitate to contact a representative of this division.

Very truly yours,

William A. Kelley, P.E., Chief
Division of Water Supply
Bureau of Environmental and
Occupational Health

Donald J. Greiner /STO

By: Donald J. Greiner, P.E.
Sanitary Engineer

STD:sw
Enclosures
cc: Ingham County Health Department
Lansing Board of Water & Light

City Well Analysis Results

Well #	Fe	Mn	Cu	Zn	Cd	Pb	Ag	As	Ba	Se	Hg	Cr
70-4	610	30	30	0	< 0.5	< 3	< 1	< 5	226	< 2	0.0	9
70-5	330	20	20	10	< 0.5	< 3	< 1	< 5	< 99	< 2	0.0	< 3
80-10	2780	70	20	30	< 0.5	< 3	< 1	5	114	2	0.0	< 3

NOTE: Results are listed in µg/l.

City Well Analysis Results - MDPH Lab

Well No.	Bacti (Coliform)	PCB	T.O.C.
70-4	0	* <0.1 ppb	2.7 ppm
70-5	0	* <0.1 ppb	0.4 ppm
80-10	0	* <0.1 ppb	2.3 ppm

*Below limits of detection

Ingham County Health Department

Location	Fe	Na	N	Hardness	Cl	F	SO4	TDS	pH	Analyses to be Completed PCB	Pb
6203 Aurelius	0.2	0	0.0	257	1	0.1					
	0.4	1	0.0	250	1	0.14	24	262	7.9		
10-19-78					0		22.6	262	7.8		
Granger Company	4.9	178	0.1	625	480	0.0					
Miller-Aurelius	3.6	176	0.0	640	479	0.04	83	1177	7.0		
10-19-78					87		71.1	484	7.6		
Assoc. Bldrs.	0.8	12	0.0	444	82	0.0					
Contractor	0.8	10	0.0	448	84	0.05	92	484	7.7		
6144 Aurelius											
Builders Redi-Mix	0.0	184	0.0	3	82	0.0					
6133 Aurelius	0.1	207	0.0	1	82	0.05	83	523	8.2		
10-20-78					28		60.4	366	7.7		
84 Lumber Co.	>5.5	44	0.0	>640	247	0.0					
6121 Aurelius	>5.5	46	0.0	>640	248	0.01	112	785	7.7		
10-19-78					171		96.6	667	6.8		
Lansing Floor Co.	0.2	20	0.0	93	19	0.9					
5157 Aurelius	0.1	20	0.0	92	19	0.96	70	183	8.6		
Jet Die & Eng.	1.0	29	0.0	464	97	0.2					
5300 Aurelius	1.2	28	0.0	471	98	0.19	112	536	7.7		
10-23-78					112		110.4	602	7.0		

Except where indicated, these sample results are from samples collected 5-8-79

CHEMICAL ANALYSIS OF PRIVATE WELLS

Log No.	Location	Date Collected	Depth of Well	Chloride (ppm)	Sulfate (ppm)	TDS (ppm)	COD (mg/l)	pH	Total Hardness (ppmascaco3
2-1	S.E. Corner Jolly & Aurelius	10-23-78	95 ft.	77	60.4	464		7.3	
3-1	5300 Aurelius Rd.	10-23-78	155 ft.	112	110.4	602		7.0	
3-3	Corner of Miller & Aurelius	10-19-78	86 ft.	87	71.7	484		7.6	
11-15	6121 Aurelius Rd.	10-19-78	110 ft.	171	90.6	667		6.8	
*11-15	6121 Aurelius Rd.	10-19-78		172	68.3	704	12	8.2	
11-12	6133 Aurelius Rd.	10-20-78	216 ft.	28	60.4	366		7.7	
	6141 Aurelius Rd.	10-19-78		28	52.5	379		7.4	
11-0	6203 Aurelius Rd.	10-19-78	200 ft.	0	22.6	262		7.8	
11-9	6221 Aurelius Rd.	10-23-78	155 ft.	70	77.6	445		7 5	
	6324 Aurelius Rd.	10-23-78		83	93.3	510		7.2	
11-13	N.E. Corner of Dell & Aurelius	10-19-78	125 ft.	78	57.7	464		7.7	
*11-13	N.E. Corner of Dell & Aurelius	10-19-78		79	47.7	496	27	8.2	
11-7	4004 Dell Rd.	10-20-78	145 ft.	1	8.1	275		7.6	
11-1	4069 Pine Dell	10-20-78	125 ft.	0	1.4	294		7.7	
11-5	4075 Pine Dell	10-20-78	110 ft.	0	2.2	288		8.0	
11-11	4101 Pine Dell	10-23-78	125 ft.	0	1.4	291		7.4	
11-2	4109 Pine Dell	10-20-78	116 ft.	0	7.1	301		7.7	
11-6	4054 Pine Dell	10-23-78	115 ft.	1	2.2	320		8.0	
11-4	4038 Bonneyview	10-23-78	125 ft.	1	0.6	288		7.6	

CHEMICAL ANALYSIS OF FIVE CITY OF LANSING REFERENCE WELLS

70-5	T:4N, R:2W, S:35 S.W. quad, S.W. corner	7-29-74	415.5 ft.	1	15	543.1		7.2	354
60-6	T.4N, R:2W, S:34 S.W. quad, S.E. corner	12-10-76	405 ft.	55	113			7.15	460
70-8	T:3N, R:2W, S:3 N.W. quad, S.W. corner	12-8 -76	360 ft.	5	8			7.1	304
30-10	T:3N, R:2W, S:3 S.W. quad, S.W. corner	12-15-76	410 ft.	82.5	155			7.0	418
30-9	T:3N, R:2W, S:9 N.E. quad, S.W. corner	12-15-76	398 ft.	8.5	58			6.7	334

APPENDIX V

PROJECTED QUALITY FOR VARIOUS FLOW REGIMES

TABLE V-1

Parameter	Proposed[1] Background Levels High	Low	USEPA[2] Maximum Contaminant Levels	Leachate[3] Quality - Drift Flow	Leachate[4] Quality Saginaw Flow
COD mg/l	27	1	-	168	320
Chloride mg/l	79	16	250	520	840
Sulfate	57.7	7.4	250	80	200
Nitrate mg/l	-	-	10	.23	0.57
TDS mg/l	496	293	500	2800	3600
pH	10.0	7.7	6.8-8.5	8.4	7.3
Iron mg/l	3.9	.27	0.3	10.0	125
Lead mg/l	0.47	0.04	0.05	0,07	0.03

[1]Taken from water analyses of wells OW9 and 11-13.

[2]Published in the Federal Register, September 13, 1979.

[3]Taken from water analyses of well OW1.

[4]Taken from water analyses of well MW3.

APPENDIX VI

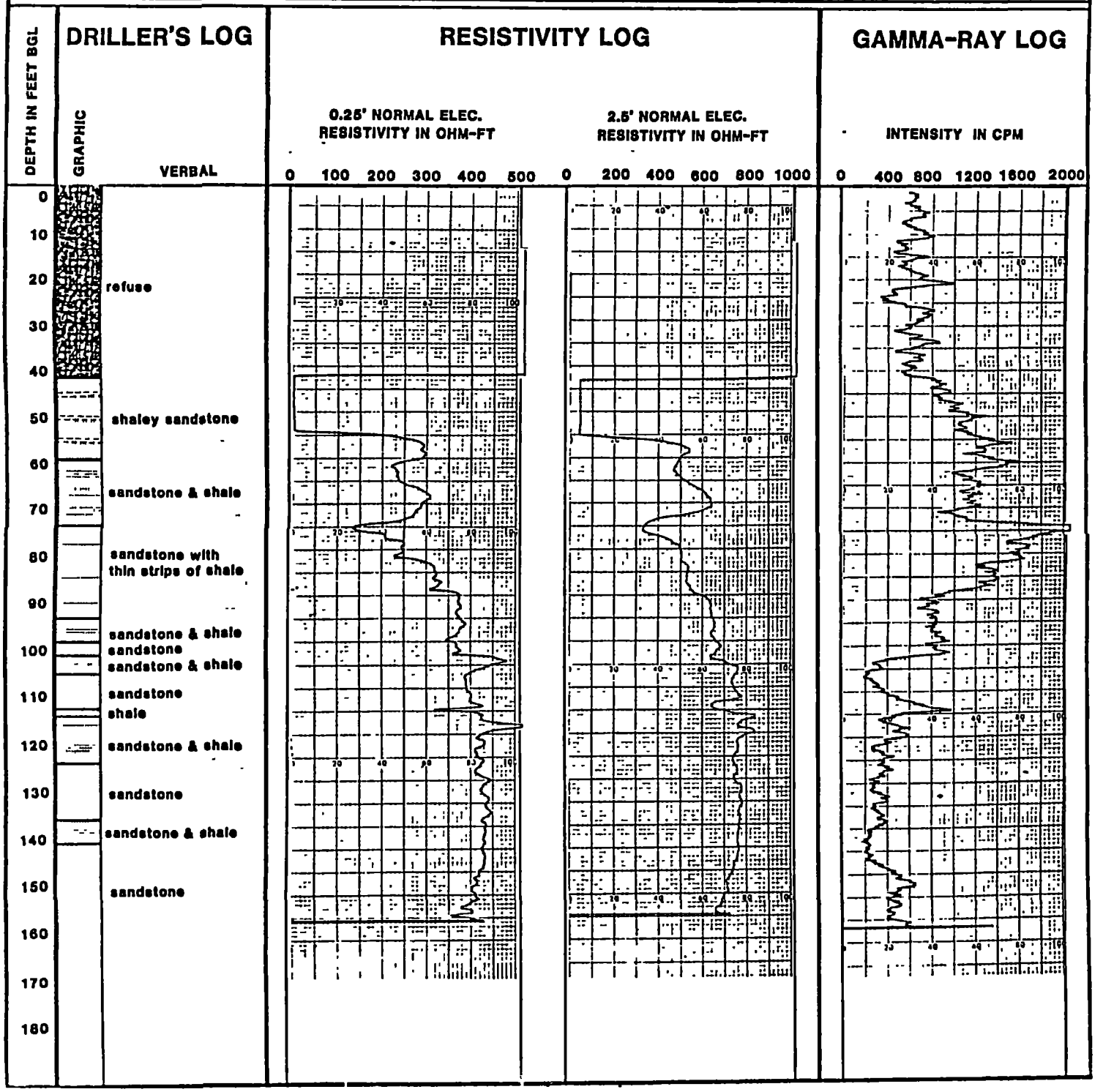
BOREHOLE GEOPHYSICAL LOGS

BOREHOLE GEOPHYSICAL LOGS

MONITOR WELL NUMBER 1

AURELIUS ROAD LANDFILL
SECTION 2, DELHI TOWNSHIP
INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION: 873.0'
DATE LOGGED: 18 AUG 79

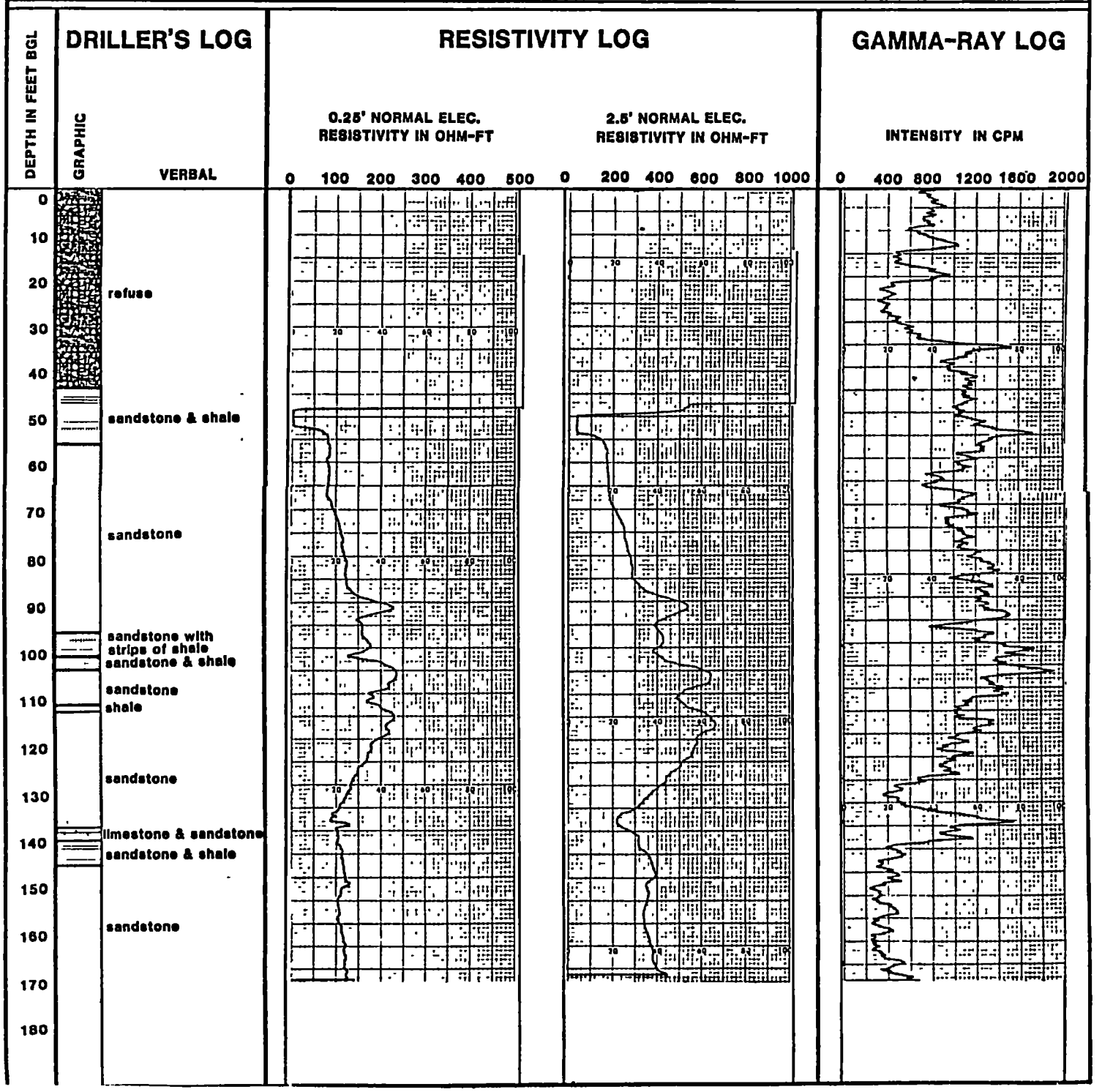


BOREHOLE GEOPHYSICAL LOGS

MONITOR WELL NUMBER 2

AURELIUS ROAD LANDFILL
SECTION 2, DELHI TOWNSHIP
INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION: 879.9'
DATE LOGGED: 18 AUG 79

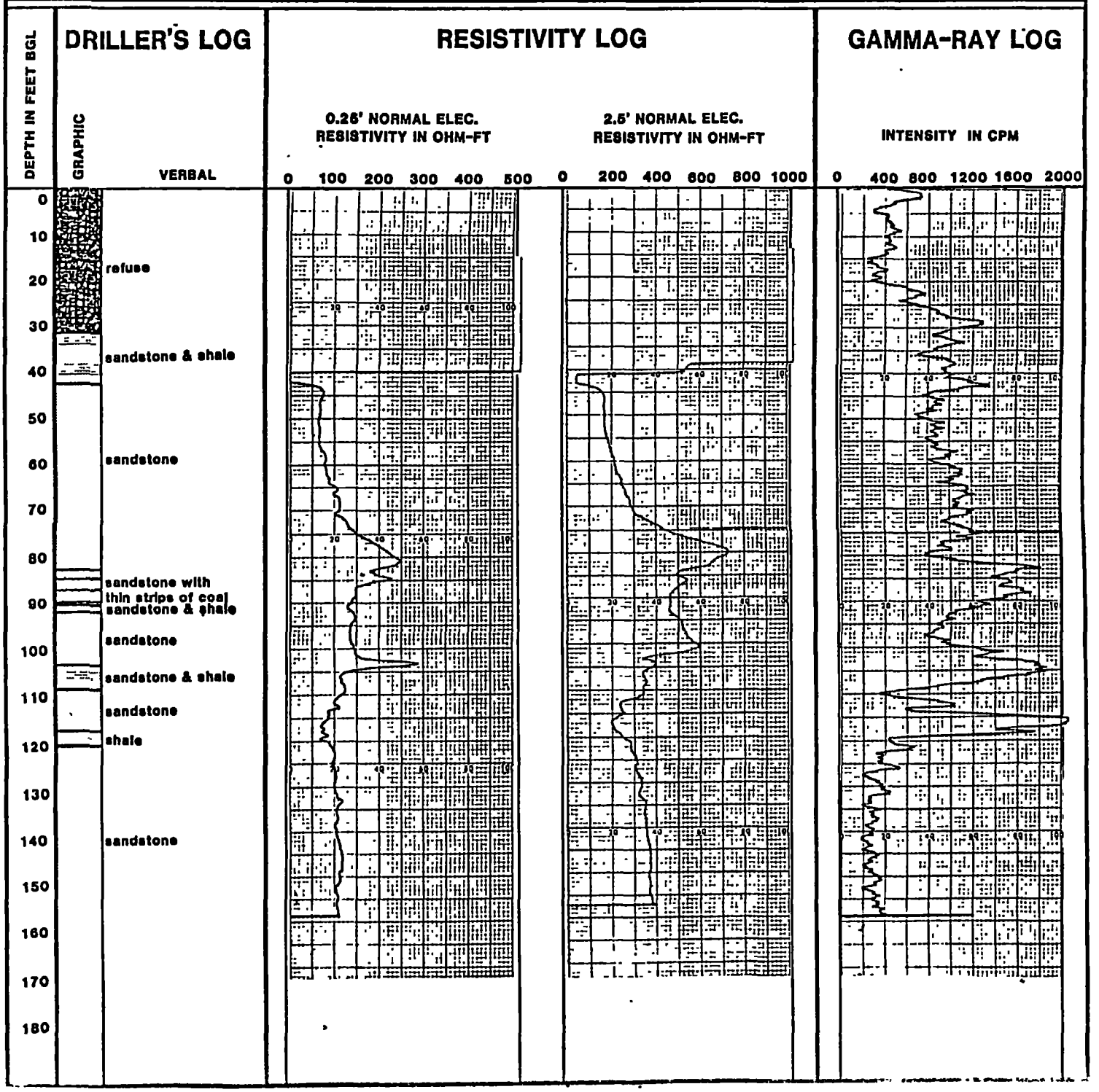


BOREHOLE GEOPHYSICAL LOGS

MONITOR WELL NUMBER 3

AURELIUS ROAD LANDFILL
SECTION 2, DELHI TOWNSHIP
INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION: 868.4'
DATE LOGGED: 18 AUG 79



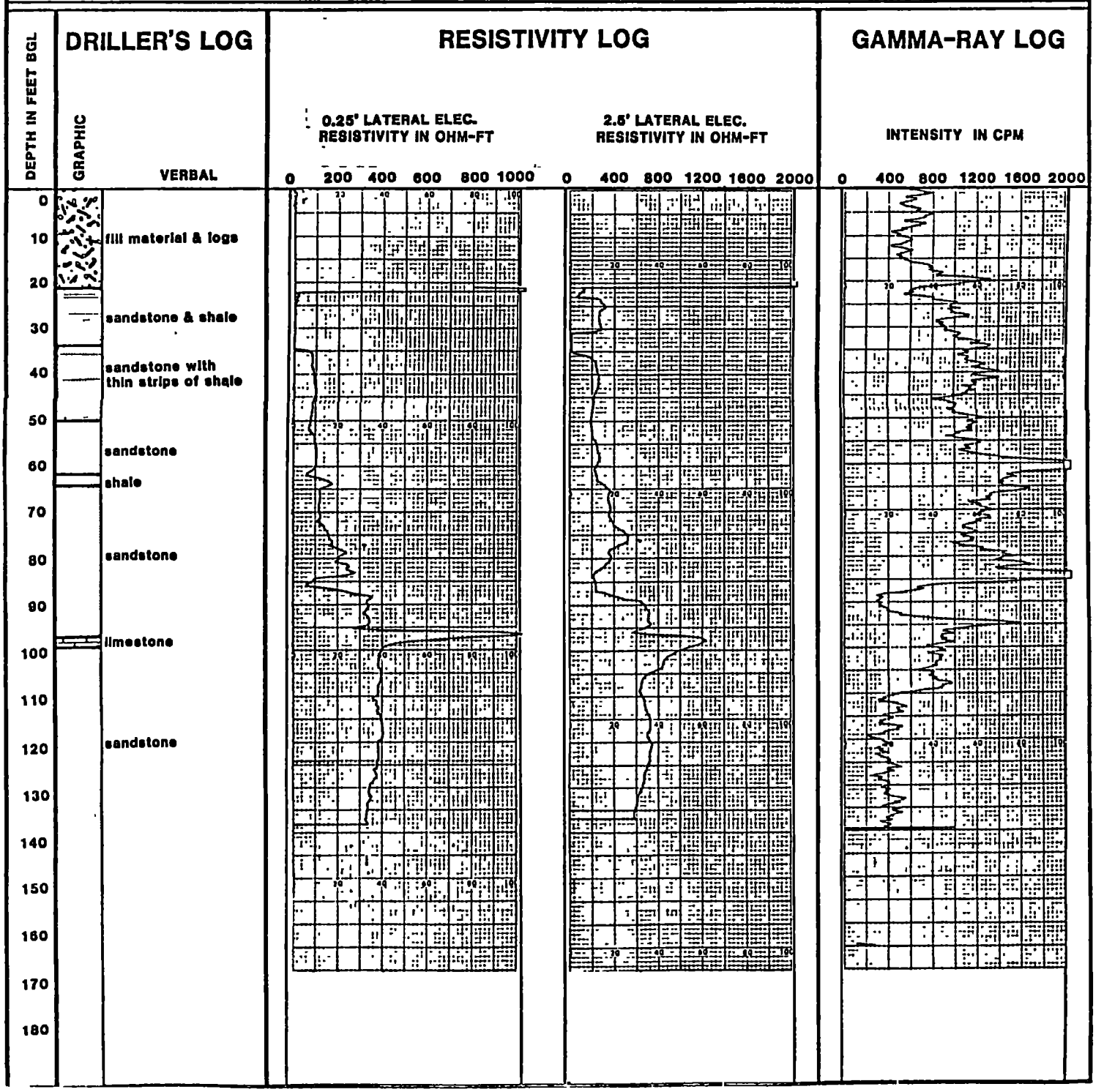
BOREHOLE GEOPHYSICAL LOGS

MONITOR WELL NUMBER 4

AURELIUS ROAD LANDFILL
SECTION 2, DELHI TOWNSHIP
INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION: 845.9'

DATE LOGGED: 7 AUG 79 & 10 AUG 79

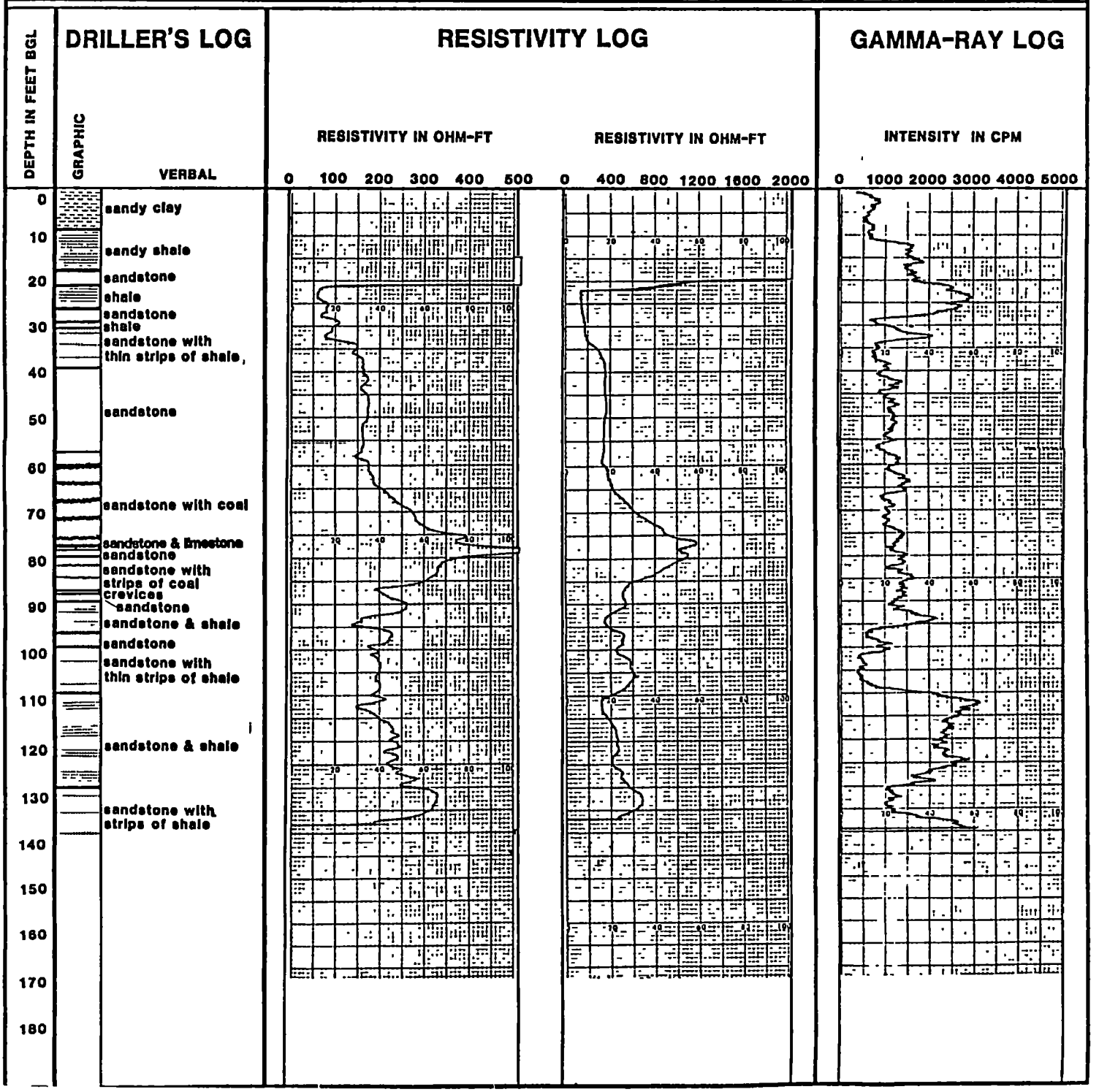


BOREHOLE GEOPHYSICAL LOGS

MONITOR WELL NUMBER 5

AURELIUS ROAD LANDFILL
SECTION 2, DELHI TOWNSHIP
INGHAM COUNTY, MICHIGAN

GROUND LEVEL ELEVATION: 849.2'
DATE LOGGED: 9 AUG 79

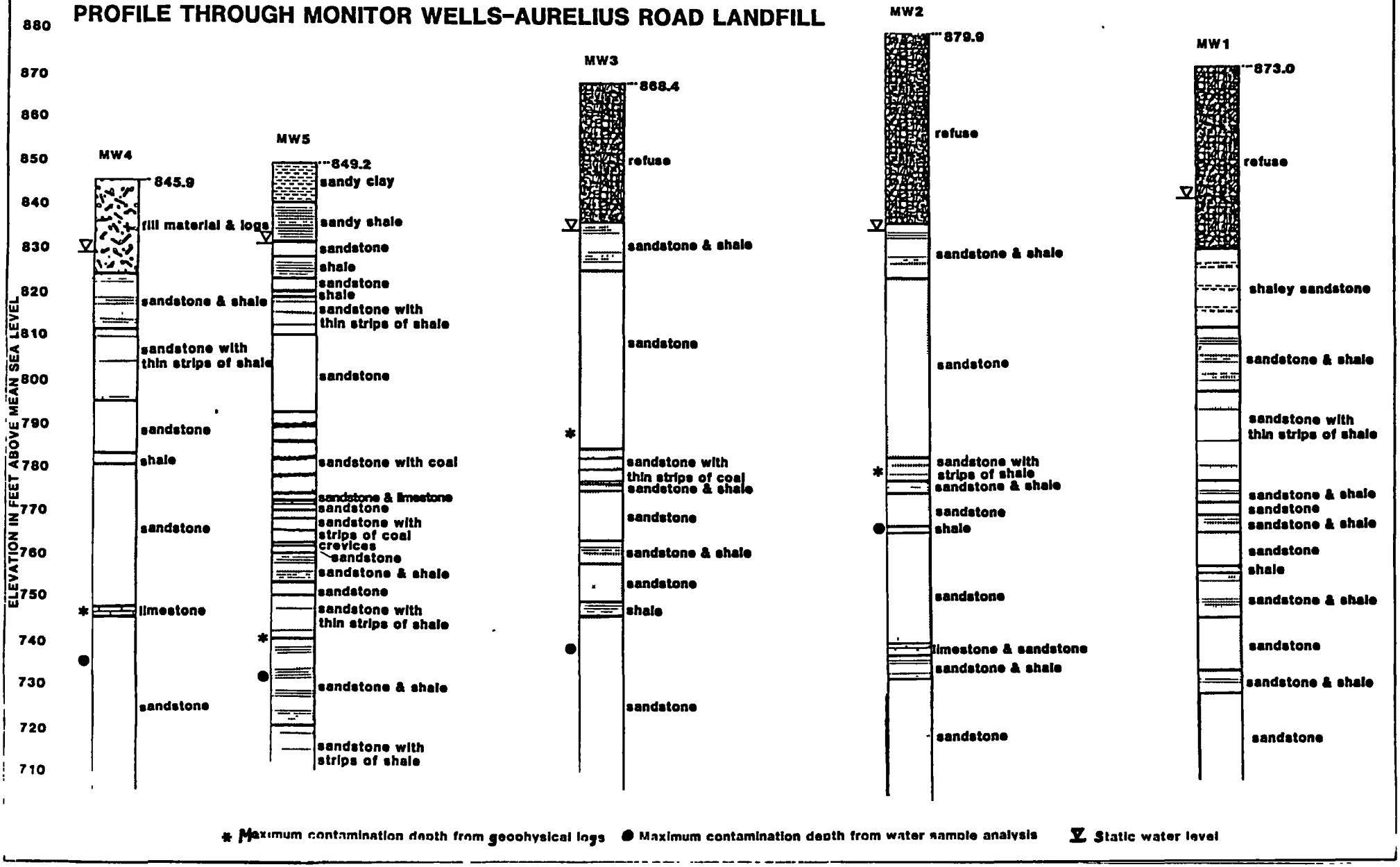


APPENDIX VII

GEOLOGICAL CROSS-SECTION

Exhibit G

PROFILE THROUGH MONITOR WELLS–AURELIUS ROAD LANDFILL



* Maximum contamination depth from geophysical logs ● Maximum contamination depth from water sample analysis ▽ Static water level

APPENDIX VIII

SUMMARY OF CHEMICAL ANALYSES FOR OW-SERIES WELLS

SUMMARY OF WELL SAMPLE ANALYSIS PERFORMED BY SNELL ENVIRONMENTAL GROUP - AURELIUS LANDFILL

:AMETER:	Well # OW1 D	OW1 S	OW2	OW3	OW4	OW5	OW6 D	OW6 S	OW7 D	OW7 S	OW8 D	OW8 S	OW9 D	OW9 S	84 Lumber Co.	Spagnuola res.
·mical Oxygen	B-1		B-2	B-5	B-6	B-7	B-8		B-9		B-10		B-11			
iand (mg/l)																
9/26/78	168	123	32													
0/19/78															12	27
0/30/78					50											
11/1/78				30		77										
1/18/79					52		52									
1/19/79		162	9	2		144		6	22		2		1			
2/16/79			35		30		10		101		53		11			
0/10/79		130														
oride (mg/l																
9/26/78	502	431	119													
0/19/78															172	79
0/30/78					74											
11/1/78				35		237										
1/18/79					50		8									
1/19/79		360	57	27		191		6	581		143		23			
2/16/79			93		109		4		631		100		27			
8/14/79	520	370	85	30	72	220	8.3	LT1	610		58		16			
!fate (mg/l)																
9/26/78	57.4	56	69.5													
0/19/78															68.3	47.7
0/30/78					37.4											
11/1/78				33.7		235										
1/18/79					23		25									
1/19/79		21	14	33		115		41	223		27		35			
2/16/79			15		32		24		210		22		54			
8/14/79	80	71	14	46	32	124	18	310	75		200		7.4			
.al Dissolved ids (mg/l)																
9/26/78	1724	1432	532													
0/19/78															704	496
0/30/78					622											
11/1/78				350		1224										
1/18/79					290		370									
1/19/79		1141	160	339		799		203	1914		348		293			
2/16/79			480		1041		456		2362		345		340			
8/14/79	2800	2200	790	990	1100	2400	770	310	1800		1200		440			
9/26/78	7.8	7.6	8.5													
0/19/78															8.2	8.2
0/30/78					8.3											
11/1/78				8.1		7.7										
1/18/79					10.6		8.4									
1/19/79		8.4	11.0	7.8		9.5		10.8	8.2		10.0		8.8			
2/16/79			9.0		7.9		7.9		8.1		9.7		8.8			
8/14/79	7.4	7.4	9.2	8.0	9.8	7.5	9.7	10.0	9.6		10.0		10.0			
·n (mg/l)																
1/18/79					2.1		5.0									
1/19/79		2.1	3.8	3.8		5.6		74	5.8		12		3.9			
2/16/79			.49		2.4		0.07		9.1		1.0		0.27			
8/14/79	2.6	10	.91	3.6	0.6	7.7	1.0	5.3	.35		1.4		1.0			
·d (mg/l)																
1/18/79					0.44		0.31									
1/19/79		0.07	0.30	0.01	0.01	0.10		0.23	0.11		0.07		0.47			
2/16/79			0.20		0.2		0.11		0.08		0.5		0.04			
8/14/79	LT.01	.03	.12	0.10	0.03	.03	.26	.51	.04		0.1		.21			
·omium (mg/l)																
1/18/79					0.03		0.02									
1/19/79		0.01	0.02	0.01		0.02		0.02	0.02		0.01		0.02			
2/16/79			0.01		0.02		0.01		0.02		0.01		0.01			
'mium (mg/l)																
1/18/79					ND		ND									
1/19/79		ND	ND	ND		ND		ND	ND		ND		ND			
kel (mg/l)																
1/18/79					0.03		0.01									
1/19/79		0.06	ND	ND	ND	0.01		0.06	0.05		0.01		0.01			

ES: [1]The following information is provided for correlation purposes:

Original Designation		Current Designation
OWA	-	OW7 Deep
OWB	-	OW8 Shallow
OWC	-	OW6
OWD	-	OW9 Shallow

[2]The "D's" and "S's" under the well designations are for deep and shallow

[3]84 Lumber Co. - 6121 Aurelius Road
Spagnuola Residence - NE corner of Intersection of Dell and Aurelius Road

APPENDIX IX

SOIL EVALUATION FOR CLAY COVER MATERIAL

BEERY
AND ASSOCIATES

October 2, 1979

Snell Environmental Group, Inc.
1120 May Street
Lansing, MI 48906

Attn: Mr. Peter Cole, P.E.

Re:

Evaluation of Soil Cover Marerials
for Landfill Site
Section 2, T3N-R2W, Delhi Twp.
Ingham County, Michigan

Exhibit A) Soil Resource Inventory Map of Section 2,
Delhi Twp., Ingham Co., MI

Dear Peter,

The soil resource inventory map for the above listed township and section has been reviewed with regards to the potential as a clay borrow area for landfill cover. The soil resources in the subject section were mapped approximately 15 years ago through a cooperative effort by the U.S.D.A. Soil Conservation Service and the Michigan Agricultural Experimant Station. Through this program the soils were classified in accordance with the present day National Cooperative Soil Survey Soil series concepts.

The review of the soil map for the section shows that the predominate soil type is the Marlette Loam (4505 B-1 & C-1,2). These are well-drained fine loamy (clayey, A-6, CL) soils developed to a depth of approximately 30-42 inches in

4868 GRANDVIEW AVENUE / OKEMOS, MICHIGAN 48864 / PHONE (517) 349-5011
SOIL CONSULTING / LAND PLANNING / SOIL AND WATER MANAGEMENT

calcareous (limey) loam (A-4, ML) glacial tills. These soils are typically located on the sloping to gently rolling and rolling upland areas of the Late Wisconsin ground and lateral moraines. Because of the naturally slow internal permeability of these soils, their surface water runoff characteristics are moderate to rapid depending upon the slope.

For the proposed use, i.e. clay cover materials, the Marlette soils will have few limitations. Because of the clayey nature of these soil materials (.002 mm clay content 25-35%), it will be possible to develop a very slowly permeable (10^{-7} cm/sec. or less) cover over the landfill area assuming that the materials are properly placed and compacted.

Recent moisture-density test data on similar soils indicates that a maximum dry density of 125-135 pcf (pounds per cubic foot) may be attained at an optimum moisture content of 7.5-8.5%. This same data also indicates however that the natural moisture content particularily of the fine loamy B2t horizons may range from 15% and upward or somewhat higher than the moisture content for maximum compaction.

Limitations which might be anticipated in the proposed use of the Marlette soils include poor workability and grading characteristics when the soil materials are either too wet or frozen.

Excavating and transporting of the materials may be accomplished with large self-loading scrapers. The power requirements however, will be relatively high due to the compact nature of the soil parent materials (glacial till).

The soil materials will be erosive when placed on slopes of greater than 4-6% if not stabilized by either mechanical means or re-vegetation.

Vegetation will be difficult to establish on the clayey subsoil materials of these soils. A minimum of 3 inches of topsoil should be placed on the compacted fill cover to insure more rapid re-vegetation of the area. The limitations regarding erosion control and re-vegetation will also pertain to the resulting borrow pit area.

Finally through numerous observations of the Marlette soils in this region it has not been unusual to encounter a stratum of fine to medium sands at depths ranging from 6' to 12 feet below ground level (BGL). This factor may limit the depth to which the clay borrow area may be excavated.

Associated with the Marlette soils in the project area are the Celina (5355 A & B-1), Capac (6455 A-1) and Parkhill (8805 A-1) Loam. These soils are the moderately well, somewhat poorly and very poorly drained counterparts of the Marlette series. They occur on the flatter slopes and depressional areas of the site and therefore have perched water tables at the surface to 1 and 2 feet BGL during the spring and early summer months. The other limitations of these soils are similar to those of the Marlette soils.

Other commonly associated soils of the Marlette catena were also noted in the subject section. These include the Owosso-Metea (3493 B & C-1) and Metamore Aubbeenaubbee sandy loams. These are well to somewhat poorly drained soils

developing in 18-42 inches of sandy loam (A-2, SM) and sandy clay loam (A-6, SC) outwash overlying the loam glacial till. These soils may or may not be useful as cover materials depending upon the depth and texture of the loamy outwash caps.

Also noted were isolated areas of outwash soils which include the Oshtemo, Boyer and Spinks sandy loams (2552, 2342, 2343). These soils would not be well-suited for cover materials due to their sandy textures.

Finally through this review it was found that several relatively small closed depressions exist about the area. The soils type found in these locations is the Carlisle muck which consists of organic materials greater than 50 inches in depth. These soil areas are unsuited for cover due to the organic materials and constant water tables at or near the surface throughout the entire year.

In conclusion it appears that major areas of the well-drained clayey Marlette soils exist throughout the subject section. These soils will be an excellent source of cover materials for theis landfill aside from the limitations discussed previous. It is recommended however if the plans are to proceed with the use of the Marlette soils as a source of cover materials, that additional on-site observations and laboratory test be performed to verify the stated soil conditions.

Sincerely yours,

Maynard Beery

Maynard Beery CPSS
Certified Professional
Soil Scientist

MB/gs

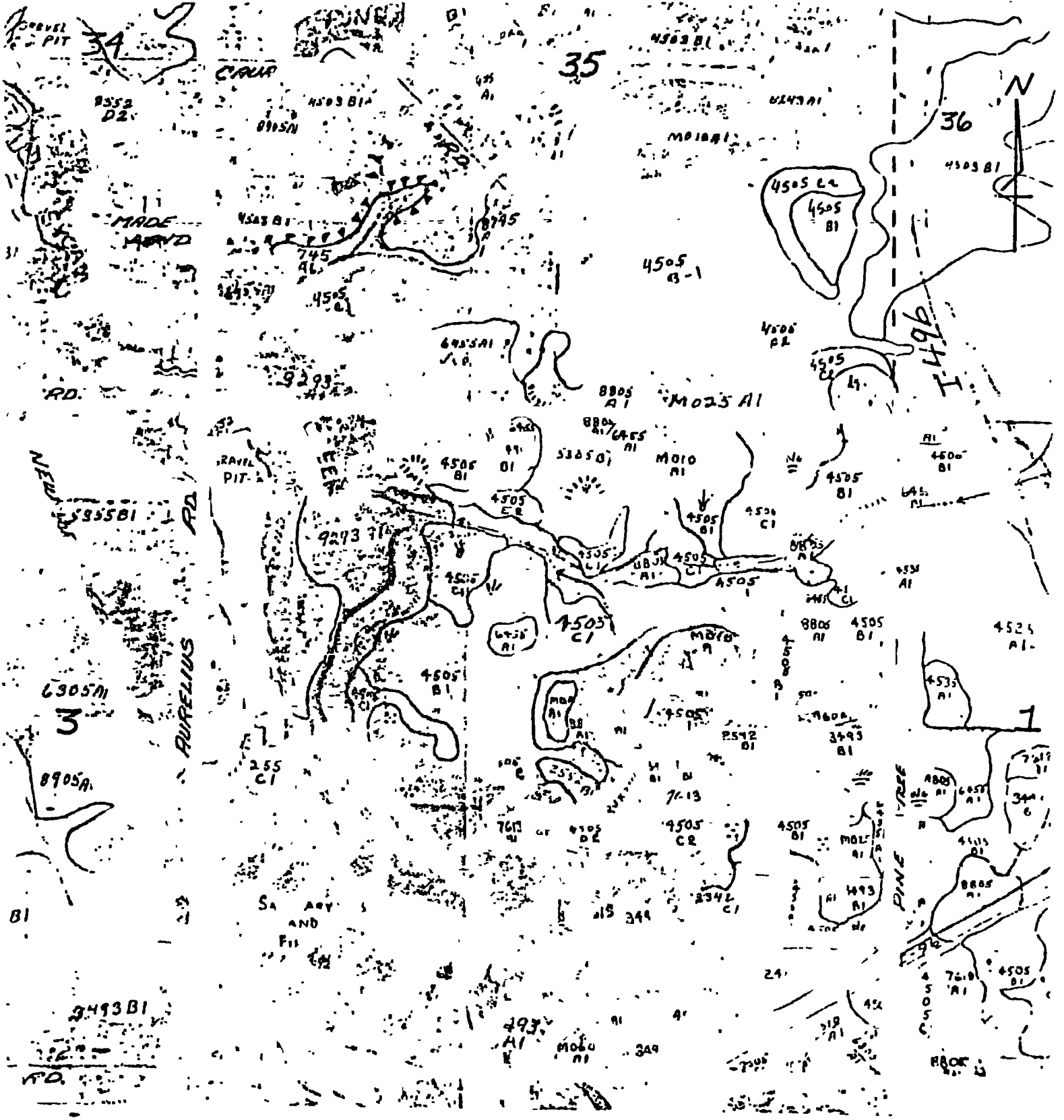
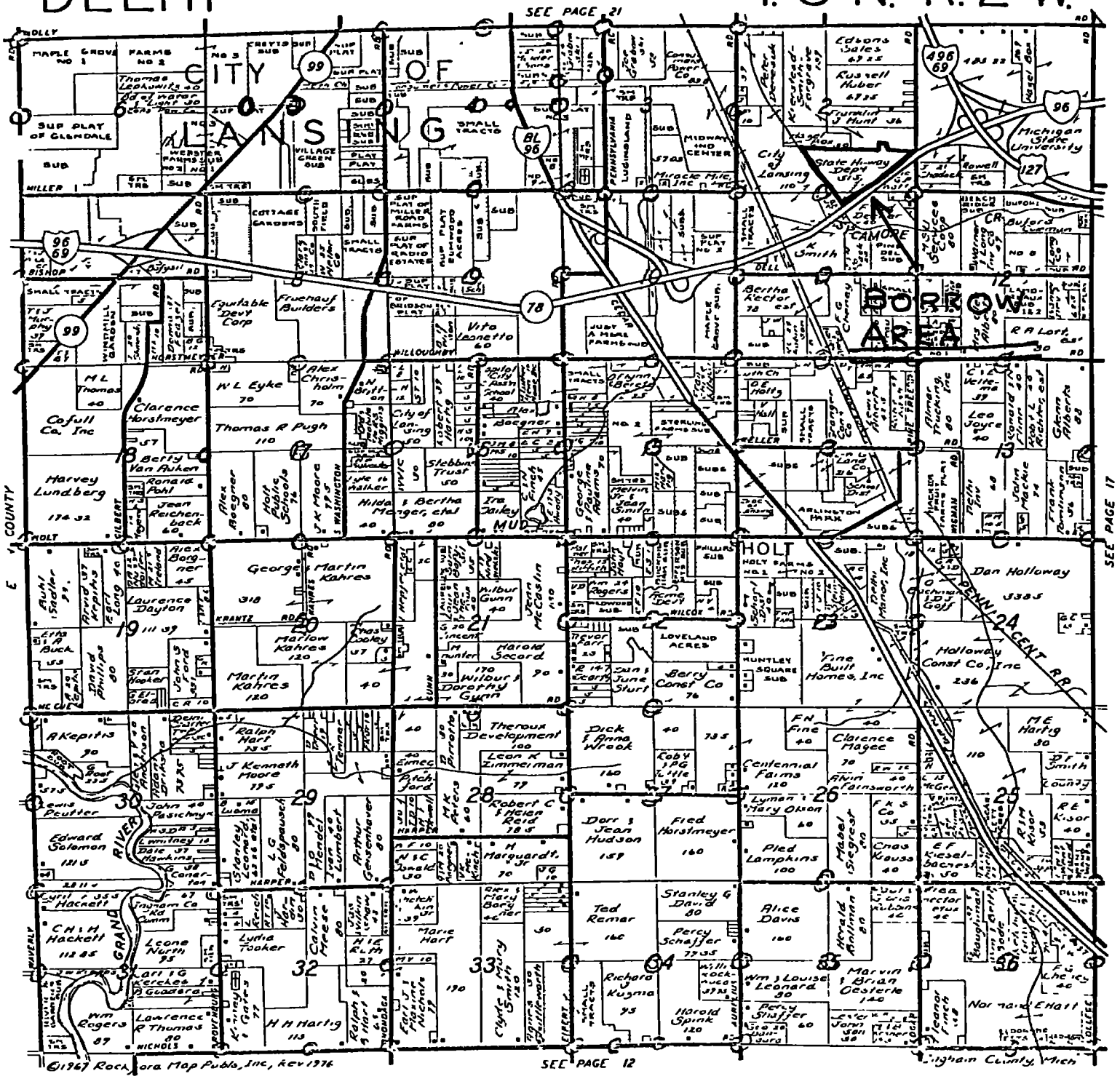


Exhibit A Soil Resource Inventory Map
Sec. 2, Delhi Township, Ingham County, Michigan

Scource: USDA Soil Conservation Service, Michigan Agricultural Experiment Station

Property Line Information added by Snell Environmental Group


DELHI
T. 3 N.–R. 2 W.
SEE PAGE 21
CITY OF LANSING
DORROW AREA
HOLT
SEE PAGE 17
SEE PAGE 12
EATON COUNTY
GRAND RIVER
MICHIGAN CENTRAL RR
Michigan State University
Cofull Co. Inc
Harvey Lundberg
George & Martin Kahres
Dan Holloway
Vine Built Homes, Inc
Holloway Const Co. Inc
Centennial Farms
Edward Solomon
Ted Remar
Alice Davis
Wm & Louise Leonard
Marvin & Brian Oesterle
Norman E Hall
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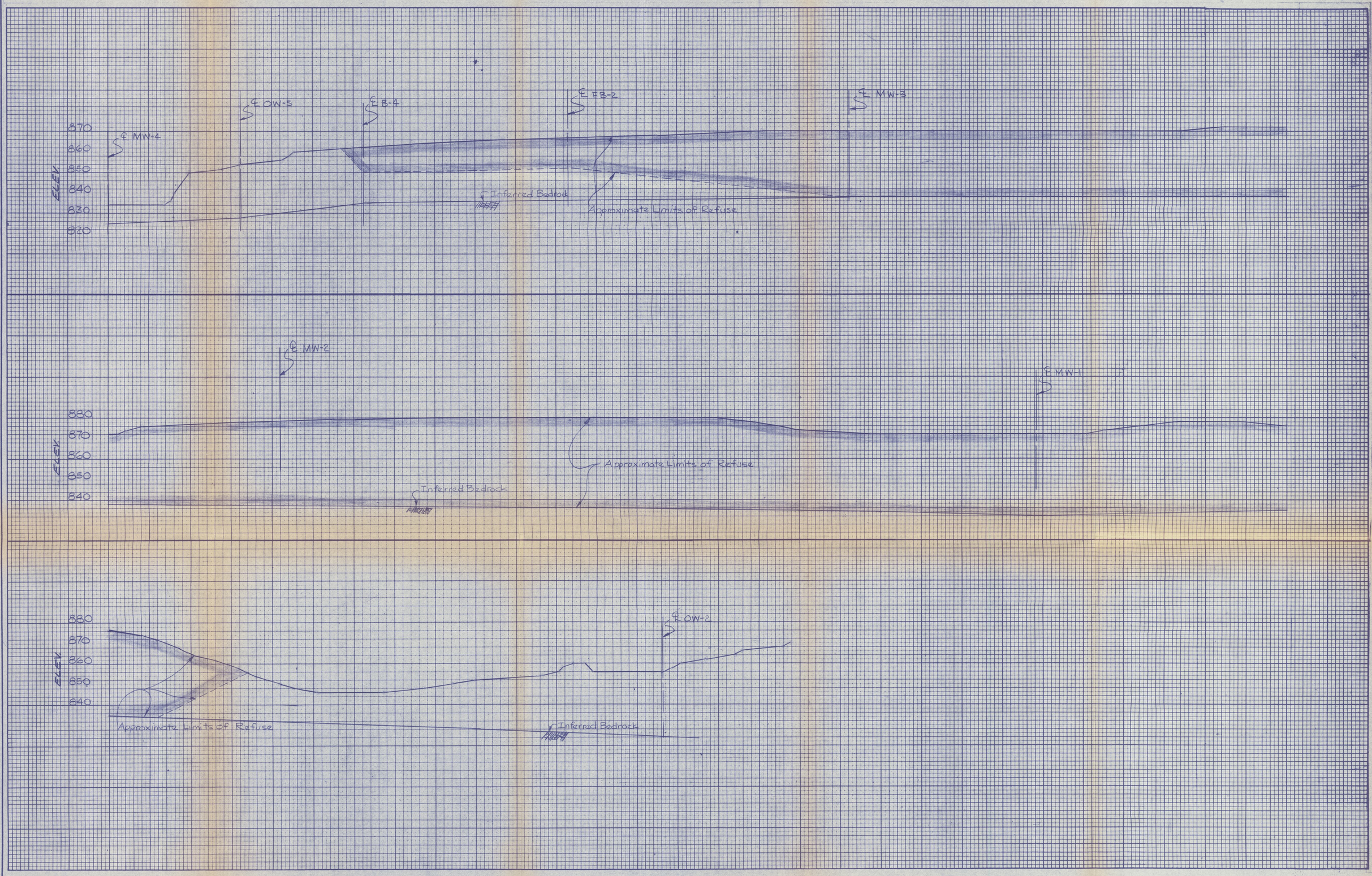
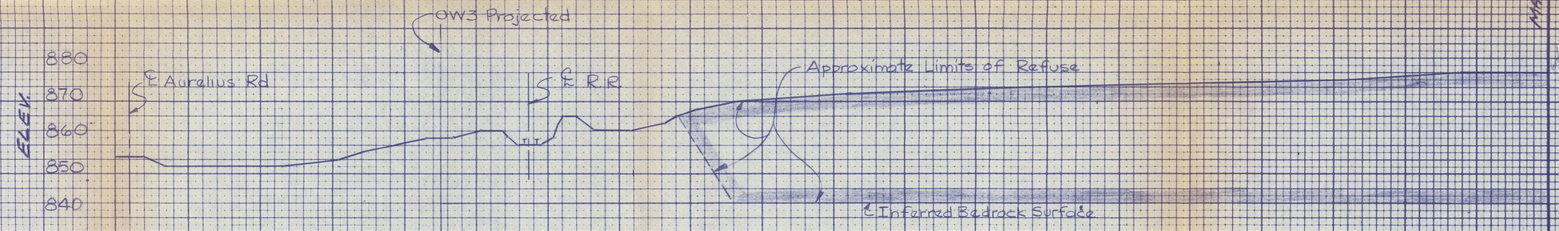
Ingham County, Mich

BRUNING 74838•

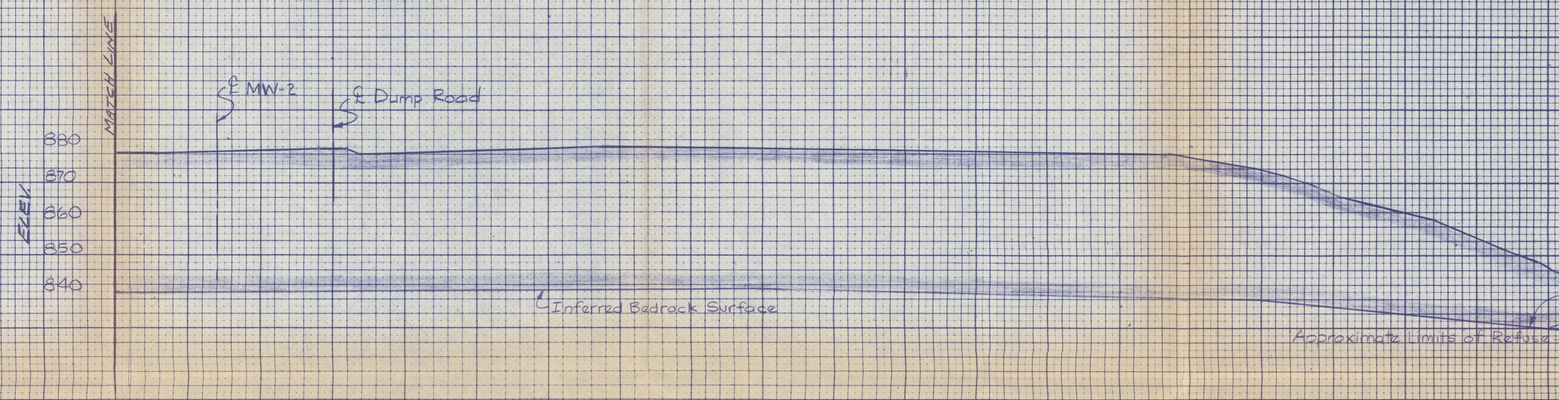


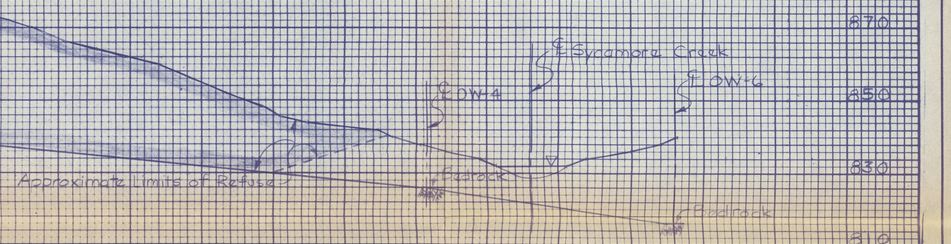
DR'N BY:	M.D.H	10-18-79	REVISIONS		CITY OF LANSING	Snell Environmental Group LANSING INDIANAPOLIS AKRON	AURELIUS ROAD LANDFILL
CK'D BY:							CROSS SECTION THRU MW-4, OW-5, B-4, FB-2, MW-3, MW-2, MW-1 & OW-2 LOOKING EAST EXHIBIT A
APP'D BY:							SCALE: VERT: 1"=20' HORZ: 1"=50'
DSGN BY:	P.F.C.	11/79					DRN. NO: 3 OF 3

BRUNING 74838•



MATCH LINE





DR'N BY:	MDH	10/18/79	REVISIONS	CITY OF LANSING	Snell Environmental Group LANSING INDIANAPOLIS AKRON	AURELIUS ROAD LANDFILL	CROSS SECTION E-W THRU MW-2 LOOKING NORTH EXHIBIT A	SCALE: VERT: 1"=20' HORZ: 1"=50'
CK'D BY:								DRN. NO: 2 OF 3
APP'D BY:								
DSGN BY:	P.F.C.	11/79						

N

N 429,500 N 429,000 N 428,500 N 428,000 N 427,500 N 427,000 N 426,500 N 426,000 N 425,500 N 425,000

E 951.5 E 950.500 E 949.500 E 948.000

OW-9

OW-1

OW-4

OW-2

MW-4

I-96

Sycamore Creek

Corp. Boundary

B-3

Zone of Contamination Migration

MW-2

OW-8

MW-4

OW-5

B-4

FB-2

MW-3

Approximate Outline of Fill Area

Corp. Boundary

FB-1

CENTRAL

PENN

OW-3

Wall #3-3

Wall #11-15

Wall #11-12 6141

Wall #11-0

Wall #11-9

MW-5

OW-7

Existing 8" Sanitary Sewer

Existing Water Line

AURELIUS

Existing 10" Sanitary Sewer

LEGEND

- OW- OBSERVATION WELLS
- MW- NEW MONITORING WELLS
- STREAM SAMPLING LOCATION
- APPROXIMATE BOUNDARY OF FILL
- EXISTING CONTOUR
- WELL N-N PRIVATE WELL

DRN BY	MDH	10/18/79	SYMBOL	REVISION	DATE	
			1	WATER LINE & SECTION LINES ADDED	12/7/79	
DSGN BY	RFG	11/79				

CITY OF LANSING

Snell Environmental Group
LANSING INDIANAPOLIS AKRON

AURELIUS ROAD LANDFILL

SITE PLAN

SCALE: 1"=100'

EXHIBIT A - DWG. NO. 1 OF 3